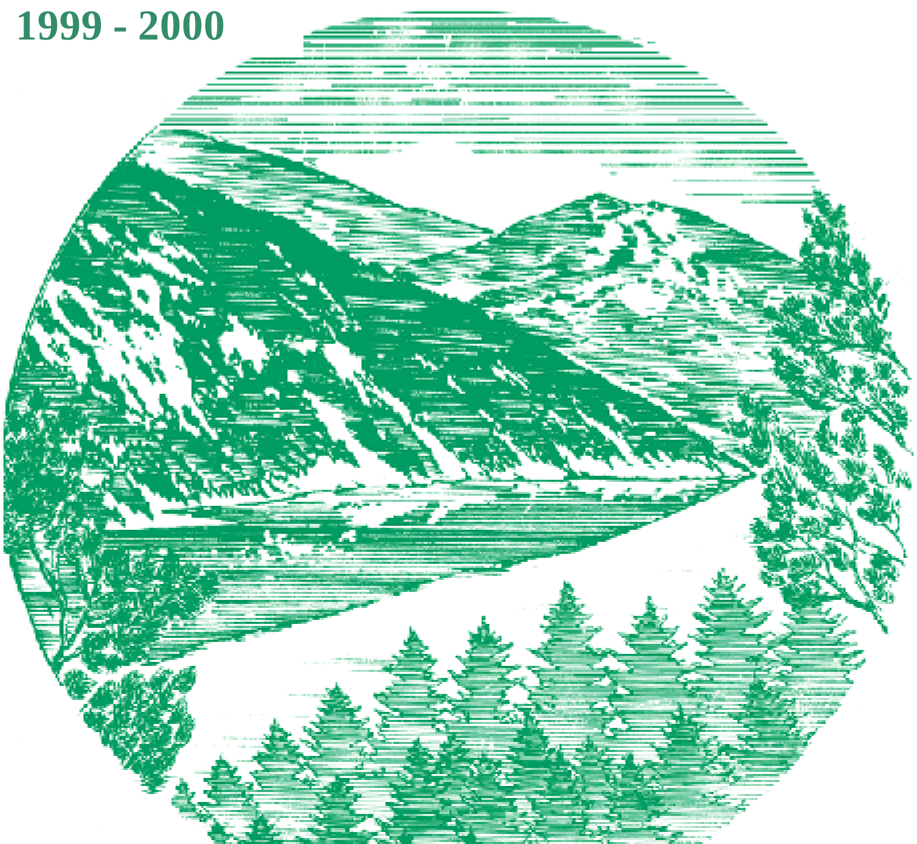
# Evaluation of the Life History of Native Salmonids in the Malheur River Basin

**Annual Report**
**1999 - 2000**



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Bonneville Power Administration
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Burns Paiute Tribe

# Evaluation of the Life History of Native Salmonids in the Malheur Subbasin

**2000 Annual Report**

**Prepared for**

**U.S. Department Of Energy**
**Bonneville Power Administration**
**Division Of Fish & Wildlife**

# Evaluation of the Life History of Native Salmonids in the Malheur River Basin (BPA project #9701900 / 9701901)
# FY 2000 Annual Report


**Prepared by:**
**Burns Paiute Tribe**
**Department of Fish and Wildlife**
Lawrence Schwabe
Steven Namitz
Jason Fenton

**-AND-**

**Oregon Department of Fish and Wildlife**
Raymond R. Perkins
Ontario, Oregon

**Montana State University**
Paul Spruell
Bozeman, Montana


**In cooperation with:**


**Burns Paiute Tribe**
**Fish and Wildlife Department**
Dan Gonzalez
Jess Wenick
Burns, Oregon

**Oregon Department of Fish and Wildlife**
Wayne L. Bowers
Hines, Oregon

**Bureau of Reclamation**
Rick W. Rieber
Boise, Idaho

**US Fish and Wildlife**
Allen J. Mauer
Bend, Oregon

**US Forest Service, Prairie City Ranger District**
Herb Roerick
Sarah Bush
Prairie City, Oregon

**Bureau of Land Management**
Cythia K. Tait
Vale, Oregon

**Investigations into the Life History of native Salmonids in the Malheur River Basin (BPA project #9701900 / 9701901)**
**FY 2000 Annual Report**

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## General Introduction

The Malheur basin lies within southeastern Oregon (Figure 1). The Malheur River is a tributary to the Snake River, entering at about River Kilometer (RK) 595 (Figure 1). The hydrological drainage area of the Malheur River is approximately 12,950 km$^2$ and is roughly 306 km in length. The headwaters of the Malheur River originate in the Blue Mountains at elevations of 6,500’ to 7,500’, and drops to an elevation of 2000’ at the confluence with the Snake River near Ontario, Oregon. The climate of the Malheur basin is characterized by hot dry summers, occasionally exceeding 38$^{o}$C and cold winters that may drop below –29$^{o}$C. Average annual precipitation is 300 centimeters and ranges from 100 centimeters in the upper mountains to less than 25 centimeters in the lower reaches (Gonzalez 1999). Wooded areas consist primarily of mixed fir and pine forest in the higher elevations. Sagebrush and grass communities dominate the flora in the lower elevations.

Efforts to document salmonid life histories, water quality, and habitat conditions have continued in fiscal year 2000. The Burns Paiute Tribe (BPT), United States Forest Service (USFS), and Oregon Department of Fish and Wildlife (ODFW), have been working cooperatively to achieve this common goal. Bull trout *Salvenlinus confluentus* have specific environmental requirements and complex life histories making them especially susceptible to human activities that alter their habitat (Howell and Buchanan 1992). Bull trout are considered to be a cold-water species and are temperature dependent. This presents a challenge for managers, biologists, and private landowners in the Malheur basin. Because of the listing of bull trout under the Endangered Species Act as threatened and the current health of the landscape, a workgroup was formed to develop project objectives related to bull trout. Individuals that participated in the 2000 work group are listed in Table 1.

**Table 1.** Participants and associated organization present for the 2000 Bull Trout Workgroup meetings.

| Organization | Participant |
|---|---|
| **Burn Paiute Tribe** | Daniel Gonzalez |
| | Lawrence Schwabe |
| | Mark Tiley |
| | Jason Fenton |
| **US Bureau of Reclamation** | Rick Rieber |
| | Tammi Salow |
| **Oregon Department of Fish and Wildlife** | Wayne Bowers |
| | Ray Perkins |
| | Tim Unterwegner |
| **US Bureau of Land Management** | Cynthia Tate |
| | Brain Lampman |
| **US Forest Service** | Alan Mauer |
| | Alan Miller |
| | Herb Roerick |
| | Sarah Bush |

This report will reflect work completed during the Bonneville Power contract period starting 1 April 2000 and ending 31 March 2001.

The study area will include the North Fork Malheur River and the Upper Malheur River from Warm Springs Reservoir upstream to the headwaters (Figure 1.).


**Figure 1.** Malheur Basin Location Map

# Radio Telemetry to Document Movements of Bull Trout in the North Fork Malheur Basin in Oregon

Author: Lawrence Schwabe, Burns Paiute Tribe Fish and Wildlife Department, Burns, Oregon

## Introduction

In 1999, bull trout *Salvelinus confluentus* were collected in the North Fork Malheur basin and implanted with radio tags. Twenty bull trout were released above Agency Dam and five released below (Schwabe 2000). Of the bull trout implanted with radio tags in 1999, ten bull trout still had active radios in 2000. Nine were above Agency Valley Dam and one below. Five radio tagged fish had 11-gram radio transmitters and the remaining five had 17-gram radio transmitters. All radio transmitters have exceeded the manufacture's guaranteed life expectancy. Tracking these bull trout would provide additional migratory data for bull trout in the North Fork Malheur basin. No additional fish were radio tagged in 2000.

*2000 Research Objectives:*

1) Document the migratory patterns of adult (> 300 mm fork length) bull trout in the North Fork Malheur basin.

2) Determine the seasonal adult bull trout (>300 mm fork length) use of Beulah Reservoir.

The study area includes the North Fork Malheur River from Juntura, Oregon (RK 0) upstream approximately 60 km to the headwaters (map page 3). Radio telemetry was conducted in the North Fork Malheur basin and started in January 2000. Fish tracking continued until radio transmission was undetectable.

## Methods

*Radio Telemetry*

Radio tagged bull trout were tracked once a week until radio transmission could not be detected or battery life expired. Guaranteed battery life for the largest radio is only 208 days. All radios being tracked were past their guaranteed life expectancy. We found radios to be active for over 1 year from activation.

An Advanced Telemetry Systems (ATS) receiver, a Yagi antenna, and a 12-channel hand-held Global Positioning System (GPS) unit were used to document the location of each fish. Foot and vehicle travel were the primary means to track fish movement. Boat tracking was used to locate bull trout within Beulah Reservoir. If telemetry effort resulted in lower than expected radio detection, aerial tracking surveys were conducted. One aerial survey was conducted from a fixed winged aircraft when tagged fish entered roadless or private areas. Once fish were located with the ATS receiver, an effort to visually identify located fish was attempted. The radio frequency

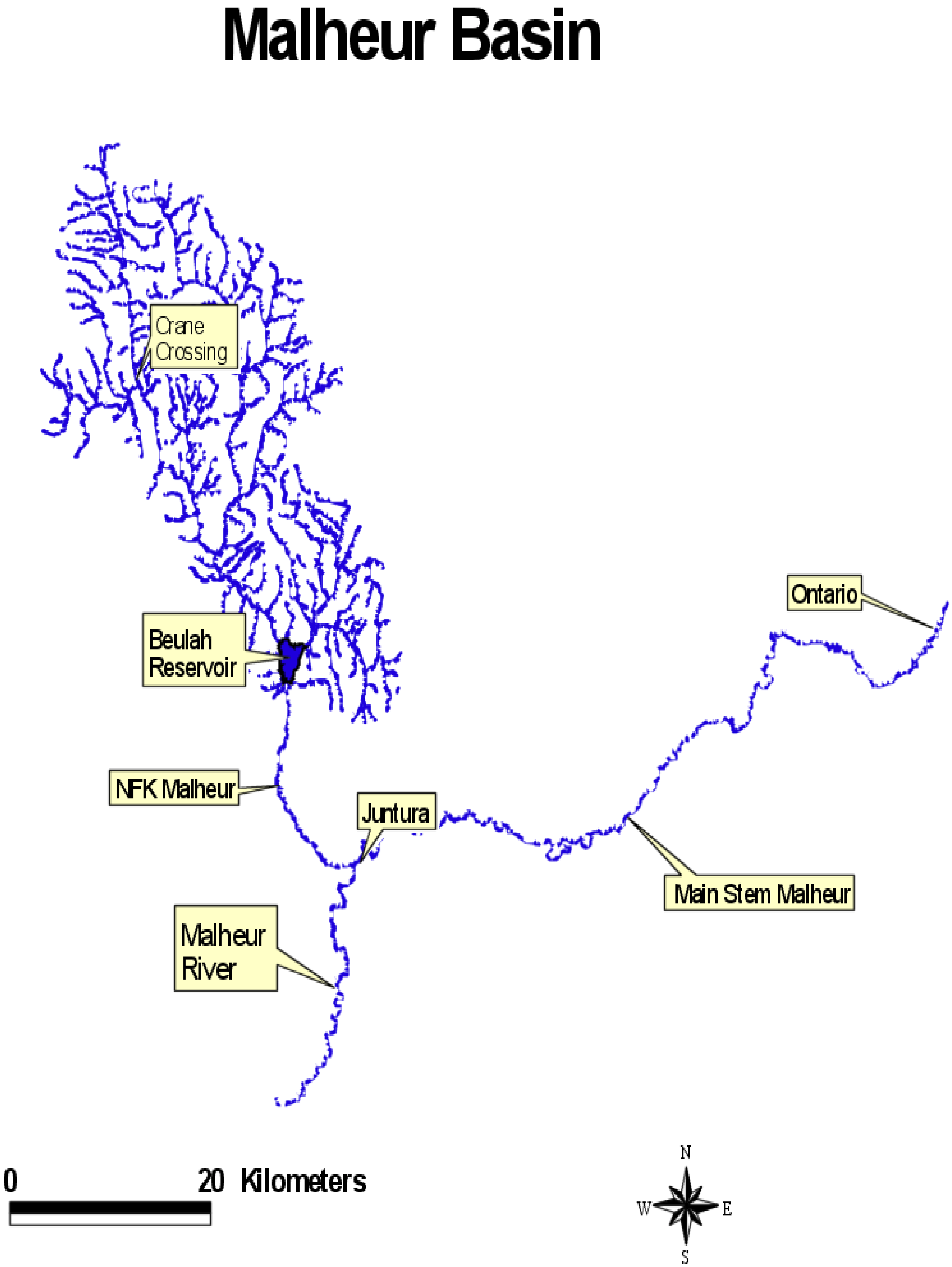



**Figure 1.** North Fork Malheur River Study Area

of each fish, the time it was located, and the Universal Transverse Mercator (UTM) location were recorded for all identifications. If applicable, additional information was taken on fish locations including stream temperatures, habitat characteristics, redds or pairing fish, and cover present.

## Results

*Telemetry Results*

The telemetry study on the North Fork Malheur River (North Fork) continued in the year 2000. Ten radio tagged bull trout implanted in 1999 were detected in 2000 (Appendix A). Of these fish, forty-two telemetry observations were documented from 29 February 2000 to 19 April 2000 (Tables 1 and 2). No radio transmissions were detected after 19 April 2000. Lack of detection was presumed to be due to battery expiration.

Table 1 – 1999 radio-tagged bull trout that were located in 2000. Fish tracking was conducted on the North Fork Malheur River basin. Detection of radio transmitters started to decrease in March and April.

| Fish Number (Frequency) | Tagging and Release Date | Number of times located in 2000 | Date of last detection |
|---|---|---|---|
| 150.433 | 4/4/99 | 4 | 3/29/00 |
| 150.522 | 4/18/99 | 7 | 4/19/00 |
| 150.922 | 4/8/99 | 6 | 4/14/00 |
| 151.023 | 4/18/99 | 8 | 4/19/00 |
| 151.133 | 4/16/99 | 1 | 3/15/00 |
| 151.152 | 4/22/99 | 2 | 3/15/00 |
| 151.182 | 6/8/99 | 4 | 4/19/00 |
| 151.192 | 4/10/99 | 7 | 4/19/00 |
| 150.433 | 4/4/99 | 1 | 3/23/00 |
| 151.593 | 4/14/99 | 2 | 3/15/00 |

Six radio-tagged bull trout from 1999 returned to the reservoir in November and December 1999 (Schwabe 2000). Tracking efforts in 2000 found all afore-mentioned bull trout in the reservoir in

February and early March. The last bull trout was found entering the reservoir on 17 March 2000. Shortly after this observation, the first bull trout was documented leaving the reservoir and entering the North Fork on 29 March 2000.

One radio-tagged bull trout was detected below Agency Valley Dam. This fish was originally released below the dam to detect bull trout movements and survivability (Schwabe 2000). Telemetry results in 2000 documented this fish 1.6 kilometers downstream on private land in the main channel of the North Fork.

Table 2 – Telemetry effort in the North Fork Malheur River basin. Number of tracking observations in 2000.

| Foot Observations | Vehicle Observations | Plane Observations | Boat Observations | Total Observations |
|---|---|---|---|---|
| 6 | 18 | 8 | 10 | 42 |

A radio tagged bull trout was located in the North Fork Malheur River at RK 46 on 15 March 2000. This fish was located on private land on a relatively remote section of the North Fork Malheur River. The flight in 2000 observed this fish in the same general location as in 1999 (Schwabe 2000). This particular fish has been observed in the same location for over one year. The landowners did not permit access to groundtruth. It is assumed this bull trout had died or expelled its tag.

## Discussion

*Radio Telemetry*

Transmission from the 1999 radio implants was not detected after 19 April 2000. Five of the eight bull trout that were tracked in the reservoir from January to early March migrated into the river by late March. It is undetermined when or if the remaining three bull trout in the reservoir migrated into the North Fork due to the loss of radio transmission and/or expired radios.

Previous telemetry efforts in 1998 and 1999 did not document bull trout migration from the reservoir into the North Fork until early April (Gonzalez 1999, Schwabe 2000). In 2000, however, bull trout were observed in the North Fork by late March, two weeks earlier than previous years.

One additional bull trout was found in the reservoir on 17 March 2000. This fish was documented at RK 7 above the reservoir 4 months earlier. The transmission of this fish was not detected for 118 days. Primary tracking efforts in January and February were conducted on foot or by vehicle. The reservoir was iced over for all of January and most of February. This fish also went undetected during the flight on 15 March 2000. It is possible that this particular fish did migrate into the reservoir in January but because of limited access and ice formation on the reservoir the radio transmission was undetectable.

For the two-year study on the North Fork, a general migratory pattern for adult bull trout (>315 mm fork length) is evident (Table 3). Fish were observed leaving Beulah Reservoir from late March to early June, with peak migration occurring in April. All fish were observed at their upper limits in mid August to early September. Fish were observed leaving the headwaters after peak spawning periods in mid-September and returning to the reservoir in late October to early January. Radio tagged bull trout were observed over wintering in the reservoir and were documented to repeat the migratory cycle in the spring.

Table 3 – Typical distribution of migratory adult bull trout (>315 mm fork length) in the North Fork Malheur River basin. Note: This only represented bull trout tagged from Beulah Reservoir and does not include the distribution of fluvial or subadult bull trout.

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| North Fork Headwaters | | | | | | | | X | X | | | |
| North Fork | | | | X | X | X | X | X | X | X | X | X |
| Beulah Reservoir | X | X | X | X | X | | | | | | X | X |


## Acknowledgements

A special thanks is extended to: Wayne Bowers (ODFW), Ray Perkins (ODFW), Rick Rieber (BOR), and Allen Mauer (USFS) who donated equipment, knowledge, and time to the project; Sarah Bush (USFS) for her time tracking fish and GIS mapping skills; Mark Tiley (BPT), Newton Skunkcap (BPT), Garrett Sam (BPT), and Jason Fenton (BPT) who spent hours of data collection in the field; and Cynthia Tate (BLM) for her participation in the work group. Bonneville Power Administration provided the funds to the Burns Paiute Tribe Fish and Wildlife Department to take the lead in this study. Bureau of Reclamation provided funds needed for extra tribal personnel.


## References


Gonzalez, D. 1999. Evaluate the Life History of Native Salmonids in the Malheur Basin. Fiscal Year 1998 Annual Report. Unpublished Data. Burns Paiute Tribe Fish and Wildlife Department. Burns, Or

Schwabe, L.T. 2000. Evaluate the Life History of Native Salmonids in the Malheur Basin. Use of radio telemetry to document bull trout movements in the Malheur River basin in Oregon. Fiscal Year 1999 Annual Report. Unpublished Data. Burns Paiute Tribe Fish and Wildlife Department. Burns, Oregon.

Appendix A – List of bull trout tracked in the North Fork Malheur River in 2000. Includes last tracked location for 1999 and all tracked locations for 2000.

| Date | Fish ID | Frequency | UTM (E) | UTM (N) | Observer | tracked by: |
|---|---|---|---|---|---|---|
| 12/21/99 | but-99-20 | 150.433 | 408624 | 4865271 | Fenton | vehicle |
| 2/9/00 | but-99-20 | 150.433 | 406648 | 4862675 | Schwabe | foot |
| 3/13/00 | but-99-20 | 150.433 | 407464 | 4866382 | Fenton | vehicle |
| 3/15/00 | but-99-20 | 150.433 | 406682 | 4865074 | Bush | plane |
| 3/29/00 | but-99-20 | 150.433 | | | tiley | vehicle |
| | | | | | | |
| 12/13/99 | but-99-21 | 150.522 | 406596 | 4864583 | Tiley | boat |
| 3/13/00 | but-99-21 | 150.522 | 408936 | 4865568 | Fenton | vehicle |
| 3/15/00 | but-99-21 | 150.522 | 408103 | 4865582 | Bush | plane |
| 3/23/00 | but-99-21 | 150.522 | 406836 | 4866367 | Fenton | boat |
| 3/30/00 | but-99-21 | 150.522 | 406692 | 4866420 | Fenton | boat |
| 4/4/00 | but-99-21 | 150.522 | 407274 | 4866543 | Fenton | boat |
| 4/14/00 | but-99-21 | 150.522 | 403917 | 4869598 | Fenton | vehicle |
| 4/19/00 | but-99-21 | 150.522 | 404034 | 4869570 | Fenton | vehicle |
| | | | | | | |
| 12/13/99 | but-98-18 | 150.922 | 406512 | 4863998 | Tiley | boat |
| 3/13/00 | but-98-18 | 150.922 | 407721 | 4862930 | Schwabe | vehicle |
| 3/15/00 | but-98-18 | 150.922 | 4007371 | 4866209 | Bush | plane |
| 3/23/00 | but-98-18 | 150.922 | 406713 | 4866264 | Fenton | boat |
| 3/30/00 | but-98-18 | 150.922 | 406810 | 4866316 | Fenton | boat |
| 4/4/00 | but-98-18 | 150.922 | 407274 | 4866543 | Fenton | boat |
| 4/14/00 | but-98-18 | 150.922 | 401753 | 4871778 | Fenton | vehicle |
| | | | | | | |
| 12/6/99 | but-99-27 | 151.023 | 407404 | 4861498 | Schwabe | vehicle |
| 2/9/00 | but-99-27 | 151.023 | 407302 | 4861556 | Schwabe | vehicle |
| 3/13/00 | but-99-27 | 151.023 | 407459 | 4861600 | Fenton | vehicle |
| 3/15/00 | but-99-27 | 151.023 | 407352 | 4862833 | Bush | plane |
| 3/17/00 | but-99-27 | 151.023 | 407459 | 4861600 | Fenton | vehicle |
| 3/29/00 | but-99-27 | 151.023 | | | tiley | vehicle |
| 4/4/00 | but-99-27 | 151.023 | | | Fenton | vehicle |
| 4/14/00 | but-99-27 | 151.023 | 407207 | 4861635 | Fenton | vehicle |
| 4/19/00 | but-99-27 | 151.023 | 407207 | 4861635 | Fenton | vehicle |
| | | | | | | |
| 11/18/99 | but-98-6 | 151.133 | 399881 | 4872755 | Mauer | plane |
| 3/15/00 | but-98-6 | 151.133 | 399247 | 4873737 | Bush | plane |
| | | | | | | |
| 12/21/99 | but-99-28 | 151.152 | 407889 | 4863962 | Fenton | foot |
| 2/9/00 | but-99-28 | 151.152 | 408019 | 4863855 | Schwabe | foot |
| 3/15/00 | but-99-28 | 151.152 | 408476 | 4865124 | Bush | plane |
| | | | | | | |
| 11/18/99 | but-99-30 | 151.182 | 400318 | 4872550 | Mauer | plane |
| 3/17/00 | but-99-30 | 151.182 | 406739 | 4862791 | Fenton | vehicle |
| 3/29/00 | but-99-30 | 151.182 | | | tiley | foot |
| 4/14/00 | but-99-30 | 151.182 | 402550 | 4870527 | Fenton | vehicle |
| 4/19/00 | but-99-30 | 151.182 | 400432 | 4873194 | Fenton | vehicle |

Appendix A continued.

| Date | Fish ID | Frequency | UTM (E) | UTM (N) | Observer | tracked by: |
|---|---|---|---|---|---|---|
| 12/13/99 | but-98-12 | 151.192 | 406897 | 4865843 | Tiley | boat |
| 3/15/00 | but-98-12 | 151.192 | 406311 | 4866506 | Bush | plane |
| 3/29/00 | but-98-12 | 151.192 | | | tiley | foot |
| 3/30/00 | but-98-12 | 151.192 | 406311 | 4866420 | Fenton | boat |
| 4/4/00 | but-98-12 | 151.192 | | | Fenton | boat |
| 4/12/00 | but-98-12 | 151.192 | 405980 | 4866479 | Fenton | boat |
| 4/14/00 | but-98-12 | 151.192 | 405971 | 4867368 | Fenton | vehicle |
| 4/19/00 | but-98-12 | 151.192 | 404132 | 4869512 | Fenton | vehicle |
| | | | | | | |
| 12/21/99 | but-99-20 | 150.433 | 408624 | 4865271 | Fenton | vehicle |
| 3/23/00 | | 150.433 | 406668 | 4865931 | Fenton | boat |
| | | | | | | |
| 12/13/99 | but-99-35 | 151.593 | 406952 | 4865573 | Tiley | boat |
| 2/9/00 | but-99-35 | 151.593 | 407992 | 4863681 | Schwabe | foot |
| 3/15/00 | but-99-35 | 151.593 | 406181 | 4866552 | Bush | plane |

## Use of radio telemetry to document movements of bull trout in the Upper Malheur River, Oregon

Author: Lawrence Schwabe, Burns Paiute Tribe Fish and Wildlife Department, Burns, Oregon

In 2000, research was conducted on bull trout *Salvelinus confluentus* in the Malheur River above Warm Springs Reservoir (referred to as the Upper Malheur River). Bull trout in the Upper Malheur River are at a high risk of extinction and are suppressed by habitat degradation, downstream losses, and hybridization and competition with brook trout *Salvelinus fontinalis* (Ratliff and Howell 1992).

Past fish and creel surveys have determined the current distribution of bull trout, however, little is known on the seasonal distribution of bull trout in the Upper Malheur River. Considering both the biological and political sensitivities surrounding the management of bull trout habitat, a clear understanding of their life history pattern is necessary to guide land management decisions and activities.

The Malheur River Bull Trout Workgroup developed the following objectives for bull trout (See Page 1):

1) Document the migratory patterns of adult/subadult bull trout in the Upper Malheur River.

2) Determine the seasonal bull trout use of Warm Springs Reservoir.

3) Determine the location of bull trout spawning in the Upper Malheur River.

The focus of the study area for the 2000 field season was primarily on the Upper Malheur River from Warm Springs Reservoir upstream to the headwaters (see page 3 and Figure 1). This report will reflect the research completed from 1 June 2000 to 31 January 2001.

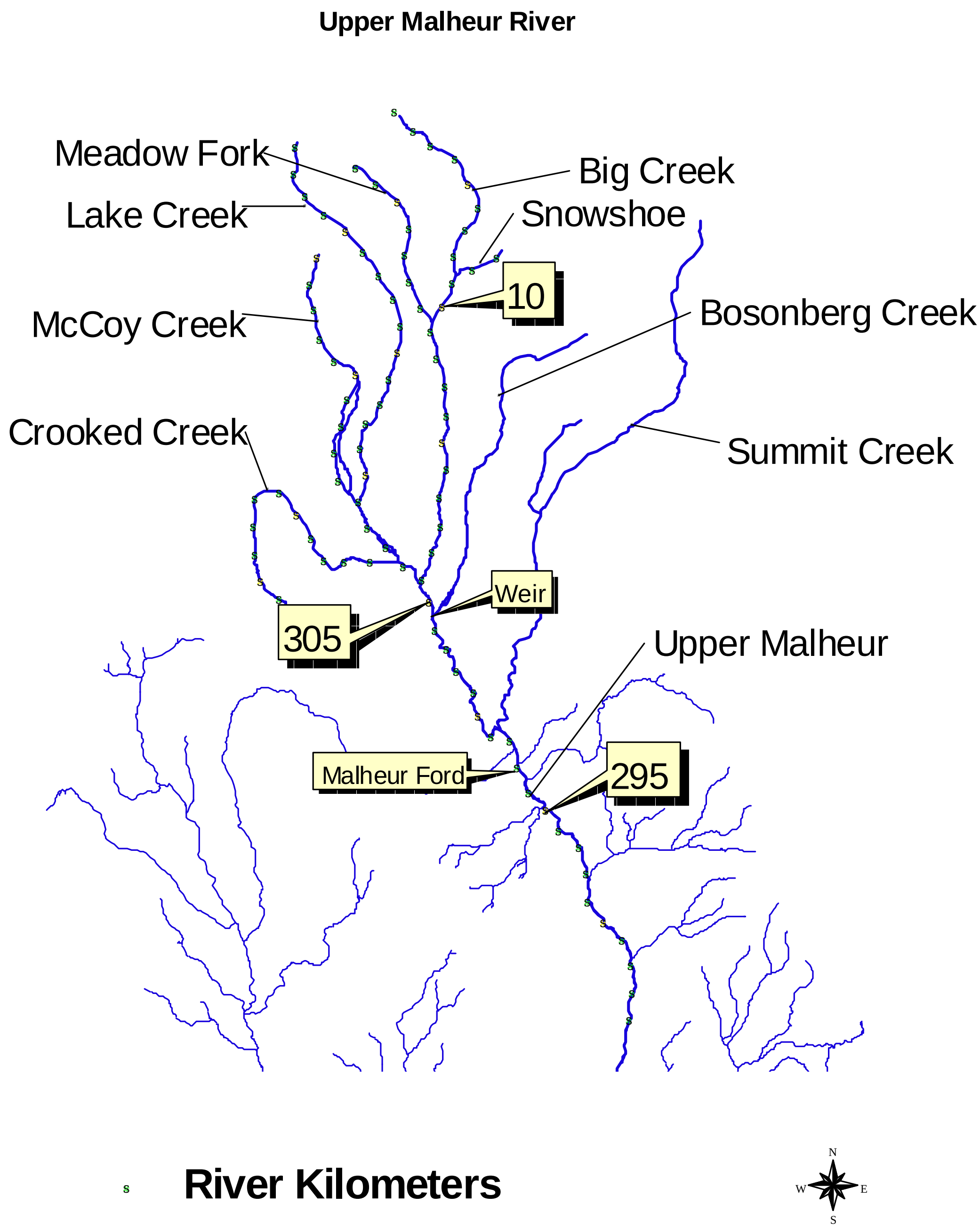



Figure 1. Study area for bull trout migration study in 2000.

## Methods

*Fish Collection*

Bull trout were collected using two methods: angling and trapping via a weir. The weir trap was set on the Upper Malheur River at River Kilometer (RK) 304 approximately 120 meters below the confluence of Bosonberg Creek. The weir trap was designed to span a width slightly larger than the wetted channel. It was installed on a slight angle across the channel. The structure was constructed of 12-foot aluminum panels that had ½ inch diameter holes. Conduit rods were spread ¼ inch apart. The weir was stabilized with fence posts that were anchored into the streambed. Weir panels were attached to the fence post with fencing wire. Upstream and downstream trap boxes were placed near opposite stream banks and interlocked into the weir panels. All fish caught in the upstream trap were released in calm water upstream from the weir site. Those caught in the downstream trap were released below the site. The Malheur River Bull Trout Workgroup were concerned of detaining endangered fish species in traps for extended periods of time. Therefore, the weir trap was checked twice a day in June when bull trout catches were relatively high and once a day from July to October.

Angling was conducted to collect additional bull trout using bait, lures, and flies with barbless hooks. Bull trout were kept in live traps until trained personnel were able to implant a radio transmitter and/or a Passive Intergraded Transponder (PIT tag). PIT tags were 12 mm long and are passive devices, meaning that the transponder carries no battery and remains inactive most of the time. The transponder's tiny electronic circuit is energized by the low-power radio beam sent by a compatible reading device. The transponder sends the ID number as a radio signal in the 134 kHz frequency band back to the scanner, which then decodes the unique number and displays it on a small screen similar to that on an electronic calculator.

Flow data were taken at the weir site. A staff gauge was installed at approximately 100 meters below the weir trap. Personnel recorded the daily staff gauge height and periodic flow measurements using a Marsh-McBirney Flow Mate flow meter. A transect was set along a homogeneous section of stream that consisted of a relatively level streambed with no major channel obstructions (i.e. boulders, logs). Along the transect, a minimum of 30 flow readings were required. All statistical analysis and calculations were performed using Microsoft Excel. Regression and $R^2$ values were used to test for relationships between staff gauge height and discharge measurements taken below the weir site.

*Radio and Passive Intergraded Transponder (PIT) Tag Implantation*

Radio transmitters manufactured by Advanced Telemetry Systems Inc. (ATS) had external whip antennas that emitted a unique frequency in either the 150 or 151 MHz band. Radios came in three sizes and are guaranteed by the manufacturer for up to 140 days (3.6 g radios), 90 days (8g radios), and 175 days (11g radios) respectively. Transmitter weight was not to exceed 3% of the bull trout body weight: 11g radio (for bull trout > 366g), 8g radio (for bull trout > 266g), and 3.6g radio (for bull trout > 120g). Bull trout weighing less than 120g were not implanted with radios.

When using PIT tags, ODFW district biologist requested that fish to be no less than 150 millimeters fork length.  PIT tag injectors and 1 ¼ inch X 12 gauge injector needles purchased from BioMark Inc. were used to insert PIT tags into the subcutaneous area of the dorsal fin.

The Malheur Bull Trout Working Group set the maximum target of 20 bull trout to be collected and radio tagged in the Upper Malheur River at the weir trap site (RK 304).  Radio tagged bull trout were released at the site of capture.

Captured bull trout were anesthetized with MS 222 (tricaine methanesulfonate), measured (fork length in mm), and weighed (g).  Radio transmitters were inserted internally through a midline internal incision (Ross and Kleiner 1982).  The external whip antennas were threaded through the body cavity and exited behind the pelvic fin, during which time the gills were bathed with diluted MS 222 (60 mg / liter) using a suction apparatus (Turkey Baster).  Absorbable surgical sutures and super glue were used to seal the incision.  After surgery, fish were held in fresh water until equilibrium was recovered, then released back into the river.  Fish tank aerators were used in all holding buckets to provide increased oxygen levels during recovery and when anesthetizing fish.

*Radio Telemetry*

The tracking of radio tagged bull trout was conducted on an average of four times a week to obtain frequent locations of each fish.  An ATS receiver, Yagi antenna, and a 12 channel hand-held GPS unit were used to locate fish.  Foot travel and a vehicle were the primary means to track individual fish.  Visual identification for the fish was preferred but rarely possible.  The frequency of each fish, time located, and Universal Transverse Mercator (UTM) location were recorded for all positive identifications.  Aerial surveys were conducted from a fixed winged aircraft when observations of tagged fish were less than expected.  Bull trout were also located by angling or by capture in the weir trap.  If applicable, additional information was taken on fish locations including stream temperatures, habitat characteristics, redds or pairing fish, and cover present.

## Results

### ***Fish Collection***

The weir trap was set on 31 May 2000 on the Upper Malheur River at RK 304 located just downstream from the confluence of Bosonberg Creek and the Upper Malheur River (Figure 1).  Ice buildup on the weir compromised its effectiveness to capture fish.  On 21 October 2000, ice blew out two panels of the weir trap.  The trap was then dismantled on 22 October 2000.  Between 01 June 2000 and 22 October 2000, the weir trap collected 66 bull trout including recaptures (Table 1).  Twenty bull trout that were collected from the trap were implanted with radio tags (Table 2).  The target of 20 implanted fish with radios was achieved by 26 June 2000.

Table 1 – Bull trout collection in the upper Malheur River basin during the 2000 field season.

| | Weir Trap | Angling | Total |
|---|---|---|---|
| Number of Bull Trout Caught | 66 | 6 | 72 |

Table 2 – The table is a list of bull trout that were radio tagged in 2000. All fish were collected at the weir trap (RK 304).

| **Date of Implant** | **Radio Frequency** | **Weight (g)** | **Fork Length (mm)** | **Maximum Distance Traveled above weir trap (km)** |
|---|---|---|---|---|
| 6/3/00 | 151.552 | 604 | 357 | 9 |
| 6/5/00 | 151.223 | 713 | 396 | 13 |
| 6/5/00 | 150.922 | 189 | 275 | 5 |
| 6/5/00 | 150.983 | 155 | 241 | 14 |
| 6/5/00 | 151.869* | 581 | 378 | 1 |
| 6/5/00 | 151.881 | 472 | 358 | 14 |
| 6/7/00 | 151.151 | 276 | 295 | 13 |
| 6/7/00 | 151.893 | 607 | 387 | 14 |
| 6/19/00 | 150.584 | 880 | 417 | 14 |
| 6/19/00 | 151.633 | 303 | 314 | 8 |
| 6/19/00 | 151.851 | 732 | 408 | 14 |
| 6/21/00 | 151.134 | 188 | 270 | 0 |
| 6/21/00 | 151.204 | 290 | 301 | 12 |
| 6/21/00 | 151.363 | 446 | 310 | 14 |
| 6/21/00 | 151.703 | NA** | 370 | 13 |
| 6/21/00 | 151.869* | NA** | 336 | 12 |
| 6/22/00 | 150.683 | NA** | 279 | 7 |
| 6/22/00 | 151.295 | NA | 297 | 14 |
| 6/26/00 | 151.171 | 136 | 240 | 0 |
| 6/26/00 | 151.195 | 309 | 305 | 13 |

** 151.869 was recovered in a dead fish one week after radio implant surgery. The radio transmitter was sterilized and put into a new bull trout on 6/21/00.*
***Weigh scale was not functioning. Weights were not taken on these fish.*

Sixty-three bull trout were caught the first ten weeks of operation (Figure 2). The fork length of bull trout ranged from 117 to 455 mm. Bull trout were primarily caught in the upstream trap from 01 June 2000 to 02 August 2000. During this period, bull trout collected in the upstream trap box represent 78% of the total catch. Four of the ten bull trout collected in the downstream trap box were recaptured in the upstream box.

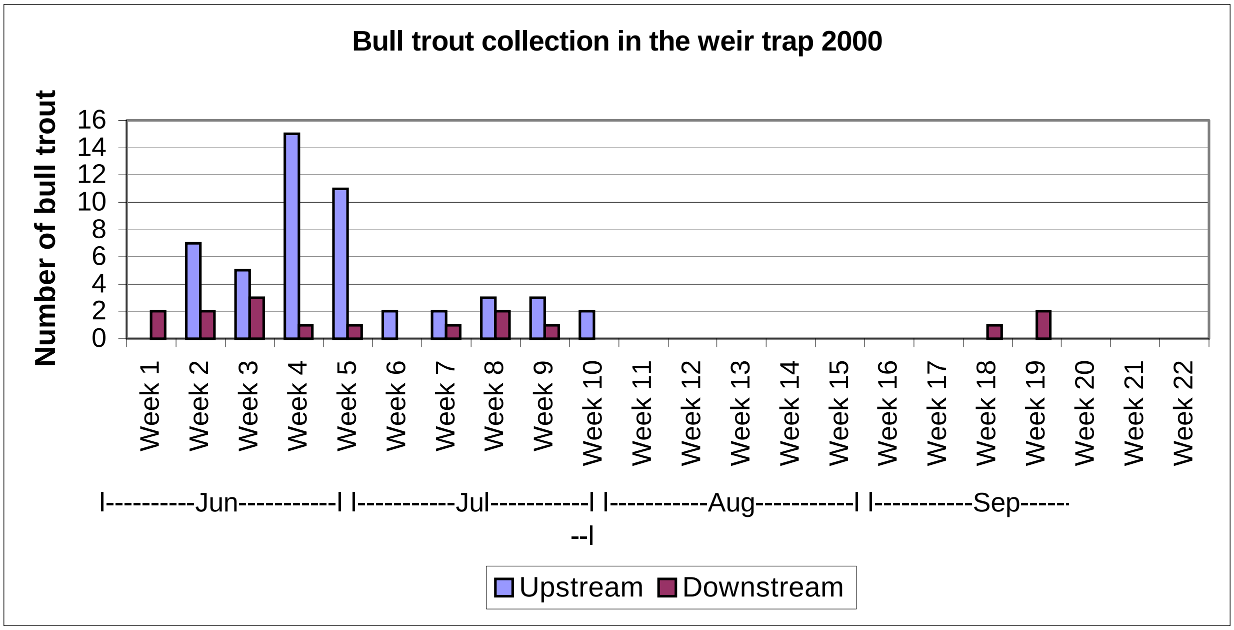



Figure 2 – Summary of bull trout catch for the weir trap in 2000. Weekly counts are figured by weekly upstream trapbox catch, weekly downstream trapbox catch, and total weekly catch.

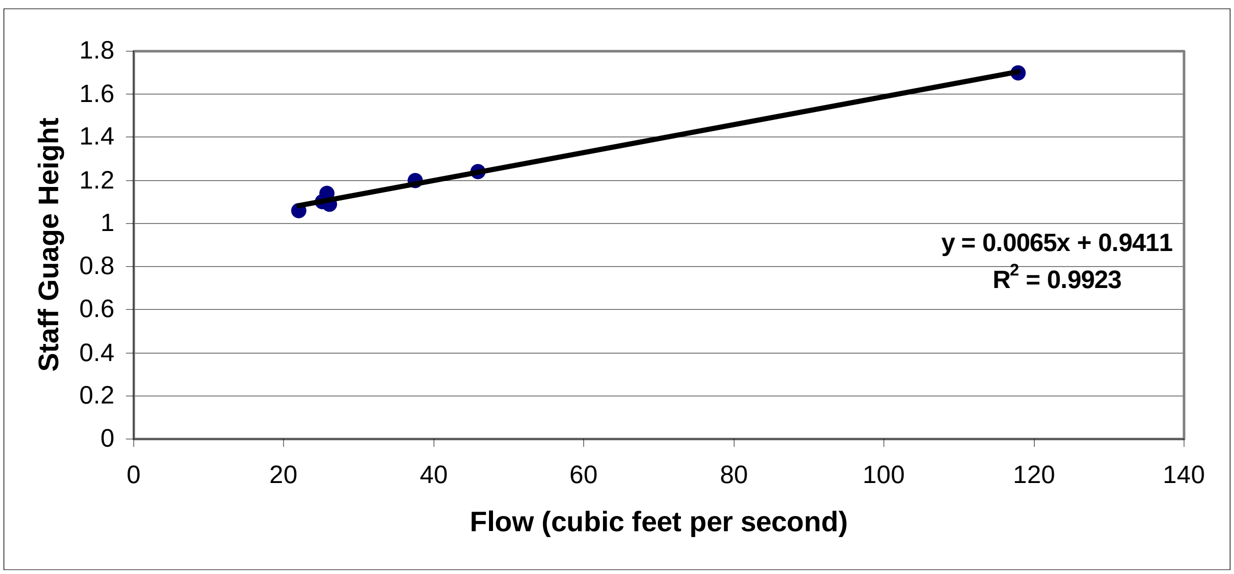



Figure 3 – Staff gauge readings were taken with every flow measurement. A total of seven flow measurements were taken from June 1, 2000 to August 30, 2000. Staff gauge height was plotted against flow. A significant relationship between the staff gauge and flow is evident.

No bull trout were collected for a 7-week period from 03 August 2000 to 23 September 2000. Three bull trout were collected in late September and early October in the downstream trap. No bull trout were caught in the upstream trap during this time period.

Other species caught in the weir trap on the Upper Malheur include: brook trout *Salvelinus fontinalis,* redband trout *Oncorhynchus mykiss,* mountain whitefish *Prosopium williamsoni*, bridgelip suckers *Catostomus columbianus*, speckled dace *Rhinichthys osculus*, longnose dace *Rhinichthys cataractae*, sculpin *Cottus spp*., and redside shiners *Richardsonius balteatus*.

A total of seven discharge readings were taken from 09 June 2000 to 31 August 2000. The staff gauge height was plotted against the associated discharge reading. A significant relationship between the staff gauge and discharge readings is evident ($y=0.0065x + 0.9411$: $R^2 = 0.9923$)(Figure 3). The regression equation was used to convert 142 daily staff gauge heights recorded to estimated daily flow for the Upper Malheur River below the weir trap (Figure 5). Daily staff gauge readings were taken from 02 June 2000 to 21 October 2000.

## Telemetry Results

A total of 343 telemetry observations were documented between 01 June 2000 to 10 January 2001 (Table 3). Most of the tracking effort was done by foot and by vehicle. The US Forest Service and the Tribe conducted two aerial tracking flights by fixed wing aircraft for radio tagged bull trout. One flight on was conducted 11 August 2000 and the other following on 04 January 2001. No fish were detected during the flight of 04 January 2001.

Table 3 – Number of tracking observations during 2000.

| **Foot Observations** | **Vehicle Observations** | **Plane Observations** | **Total Observations** |
|---|---|---|---|
| 318 | 11 | 14 | **343** |

Radio tagged bull trout that were released below the weir were all located above the trap by 22 July 2000. Fish were observed in the Upper Malheur River, Big Creek, Meadow Fork Big Creek, and Snowshoe Creek. No observations were noted in Lake Creek or its tributaries (Figure 4).

Tracking observations in July 2000 to mid August 2000 documented fish migrating upstream. The uppermost observation for each individual bull trout occurred from July 25th to September 13th. Fish were located up to 15 km above the trap site (Figure 6). Tracking observations in late August 2000 and early September find fish migrating downstream. This migration trend continued throughout the rest of the study period. By the end of November, fish were observed as far as 7 km below the weir trap site near the Malheur Ford Crossing (RK 296). Monthly observations of radio tagged bull trout can be viewed in Appendix A.

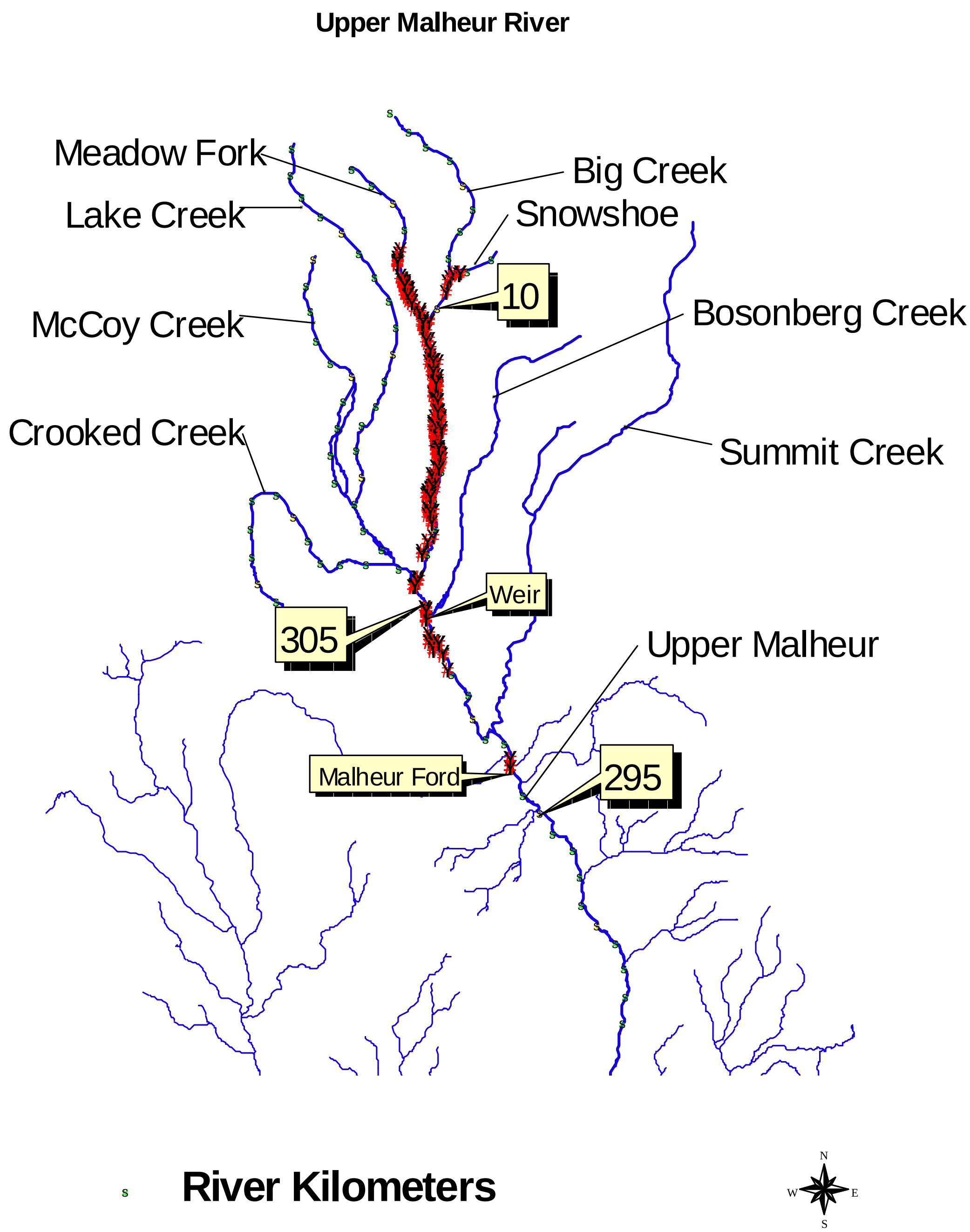



**Figure 4.** All Radio Tagged Bull Trout Telemetry Observation for 2000.

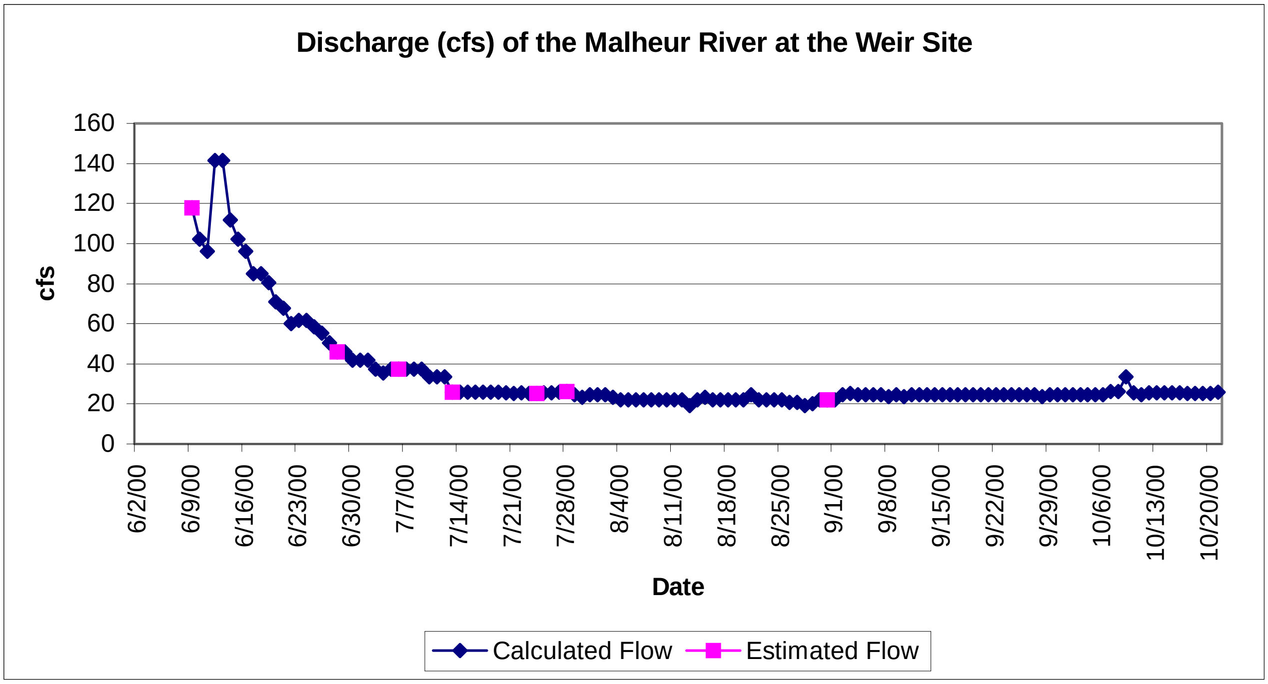



**Figure 5 –** Using the equation y=0.0065x + 0.9411, a calculated flow of the Upper Malheur River at the weir trap site can be determined. Estimated discharge was taken using a Marsh-McBirney,Inc. flow meter and an estimate flow was determined.

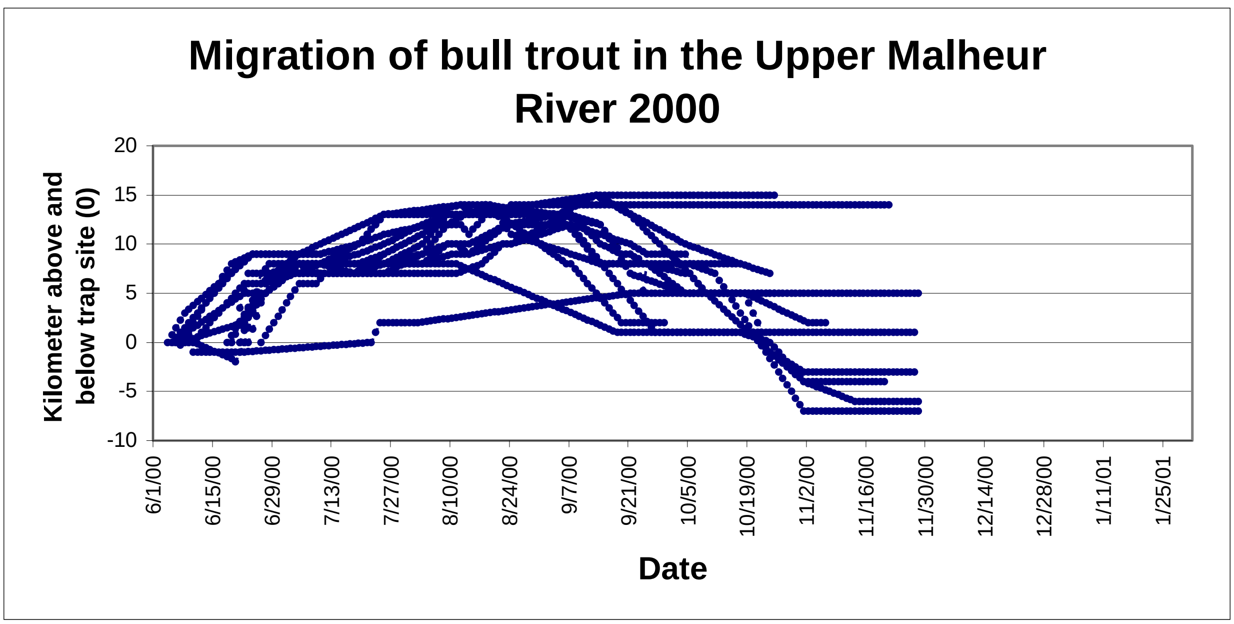



**Figure 6 –** 2000 bull trout migration. Graph includes all fish tracking observations during the field season of 2000.

## Discussion

*Fish Collection*

Data from the weir trap suggest that bull trout were migrating upstream from the Malheur River below RK 304 in June through early July. Peak collection at the weir site occurred during the fourth week of trap operation. This may not represent peak migration of bull trout at RK 304 because the weir was set in late May and there is no data for migration of bull trout for the month of May.

Six bull trout caught in the downstream trap between 03 June 2000 and 02 August 2000 were not recaptured in the upstream trap box. These fish ranged from 181 to 314 mm in fork length. It is still undetermined if these fish migrated back upstream through a gap in the weir, were lost to predation, or have over summered in the reaches below the weir trap (RK 304).

Appendix B is comprised of data collected from 2000 that includes daily flow cubic feet per second (cfs), as well as daily and total counts of bull trout. The flow regime is dominated by a falling hydrograph during the study period. Though undetermined, temperature may provide a more significant role in bull trout migration. The temperature gauge at the weir site malfunctioned but will be replaced for the 2001 field season.

*Telemetry*

Preliminary results from our first year of study on the Upper Malheur River suggest bull trout are migrating upstream from below RK 304 in June through early August. Our data suggest that migratory bull trout in this system were limited to the Big Creek drainage although in previous studies bull trout have been documented in the upper reaches of Lake Creek (Bowers et al. 1993). Of the combined total (20); 12 fish continued their migration into the Meadow Fork of Big Creek, 1 fish observed in Snowshoe Creek (a tributary of Big Creek), and 2 remained in the mainstem of Big Creek (RK 4 to 7)(Table 4). The remaining 5 radioed fish are believed to be lost to predation or anglers.

Table 4 – Number of radio tagged bull trout that were found in the following drainages. It is assumed that these fish have spawned in these drainages.

| **Drainage** | **Number of Radio tagged Bull trout** |
|---|---|
| Meadow Fork | 12 |
| Big Creek | 2 |
| Snowshoe Creek | 1 |

Spawning destinations for five fish were not determined due to the lack of data. Two fish experienced pre-spawn mortality, two fish were not detected through radio telemetry after release (3.6 gram radios), and one fish was tracked in Big Creek to Forest Service road 1648 (RK 13) on 10 July 2000 after which the fish was never detected.

Soon after spawning, bull trout were observed migrating downstream in late August and into September. Fish continued to migrate downstream and were observed near the Malheur Ford (RK 297) by the end of November. Due to the smaller radios used for implantation, many radios were undetectable by the end of November.

It is still unknown how far downstream these bull trout migrate. Some of the 3.6 gram tags from ATS Inc. were difficult to track, two of which were not tracked after the fish were released from surgery. Tracking of the remaining fish will continue in 2001 to determine over wintering areas for bull trout in the Upper Malheur River.

Bull trout collected at the weir site in 2000 were much larger than anticipated. The larger bull trout (>315 mm in fork length) collected on the North Fork Malheur River basin in 1998 and 1999 resemble in size and weight of the larger bull trout collected in the Upper Malheur River in 2000. Over 90% of the larger bull trout sampled from the North Fork Malheur River basin were collected in Beulah Reservoir. Local fishery managers suspect that they over winter in a larger body of water. In its current condition, the Upper Malheur River above Warm Springs Reservoir does not have suitable habitat, water quality, and /or prey base to sustain a healthy population of bull trout. It is assumed that bull trout in the Upper Malheur River are able to migrate down to Warm Springs Reservoir. Though migration corridors have been altered by the development of push up dams and diversions, migration down to Warm Springs Reservoir is possible at certain times of the year. With larger radio use in 2001, we anticipate to get a better idea on where and when bull trout of the Upper Malheur River migrate and over winter.

**Acknowledgements**

A special thanks is extended to: Wayne Bowers (ODFW), Ray Perkins (ODFW), Rick Rieber (BOR), and Allen Mauer (USFS) who donated equipment, knowledge, and time to the project; Sarah Bush (USFS) for her time tracking fish and GIS mapping skills; Mark Tiley (BPT), Newton Skunkcap (BPT), Garrett Sam (BPT), and Jason Fenton (BPT) who spent hours of data collection in the field; and Cynthia Tate (BLM) for her participation in the work group. Bonneville Power Administration provided the funds to the Burns Paiute Tribe Fish and Wildlife Department to take the lead in this study.

**References**

Bowers, W., P. Dupee, M. Hanson, and R. Perkins. 1993. Bull trout population summary Malheur River Basin. Unpublished Data. Oregon Department of Fish and Wildlife. Hines, OR.

Buchanan, D.V., M.L. Hanson, and R.M. Hooton. 1997. Status of Oregon's bull trout. Oregon Department of Fish and Wildlife, Portland.

Ratliff, D.E. and P.J. Howell. 1992. The status of bull trout population in Oregon. In: Howell P.J.; Buchanan, D.V. eds. Proceedings of the Gearhart Mountain bull trout worshop. Corvallis, R: Oregon Chapter of the American Fisheries Society; 37-44.

Ross, M.J. and C.F.Kleiner. 1982. Sheilded – neddle techniques for surgically implanting radio – frequency transmitters in fish. Progressive Fish – Culturist 44(1): 41 – 43.

**Appendix A.**

Daily staff gauge heights and assosiated flow readings, bull trout counts in both trapboxes and total year counts in respective trapboxes.

| Date | Flow CFS | Staff Gauge | Upstream Count | | Downstream Count | |
|---|---|---|---|---|---|---|
| | | | Daily Count | Total Count | Daily Count | Total Count |
| **6/1/00** | **NA** | **NA** | **0** | **0** | **0** | **0** |
| **6/2/00** | **NA** | **NA** | **0** | **0** | **1** | **1** |
| **6/3/00** | **NA** | **NA** | **0** | **0** | **1** | **2** |
| **6/4/00** | **NA** | **NA** | **0** | **0** | **1** | **3** |
| **6/5/00** | **NA** | **NA** | **5** | **5** | **0** | **3** |
| **6/6/00** | **NA** | **NA** | **2** | **7** | **0** | **3** |
| **6/7/00** | **NA** | **NA** | **0** | **7** | **0** | **3** |
| **6/8/00** | **NA** | **NA** | **0** | **7** | **0** | **3** |
| 6/9/00 | 117.9 | 1.70 | 0 | 7 | 0 | 3 |
| 6/10/00 | 102.2 | 1.60 | 0 | 7 | 1 | 4 |
| 6/11/00 | 96.0 | 1.56 | 0 | 7 | 1 | 5 |
| 6/12/00 | 141.4 | 1.85 | 0 | 7 | 0 | 5 |
| 6/13/00 | 141.4 | 1.85 | 0 | 7 | 1 | 6 |
| 6/14/00 | 111.6 | 1.66 | 0 | 7 | 0 | 6 |
| 6/15/00 | 102.2 | 1.60 | 2 | 9 | 0 | 6 |
| 6/16/00 | 96.0 | 1.56 | 1 | 10 | 0 | 6 |
| 6/17/00 | 85.0 | 1.49 | 2 | 12 | 1 | 7 |
| 6/18/00 | 85.0 | 1.49 | 1 | 13 | 0 | 7 |
| 6/19/00 | 80.3 | 1.46 | 1 | 14 | 0 | 7 |
| 6/20/00 | 70.9 | 1.40 | 2 | 16 | 0 | 7 |
| 6/21/00 | 67.8 | 1.38 | 4 | 20 | 0 | 7 |
| 6/22/00 | 60.0 | 1.33 | 3 | 23 | 1 | 8 |
| 6/23/00 | 61.6 | 1.34 | 2 | 25 | 0 | 8 |
| 6/24/00 | 61.6 | 1.34 | 2 | 27 | 0 | 8 |
| 6/25/00 | 58.4 | 1.32 | 1 | 28 | 1 | 9 |
| 6/26/00 | 55.3 | 1.30 | 0 | 28 | 0 | 9 |
| 6/27/00 | 50.6 | 1.27 | 2 | 30 | 0 | 9 |
| 6/28/00 | 45.9 | 1.24 | 2 | 32 | 0 | 9 |
| 6/29/00 | 45.9 | 1.24 | 2 | 34 | 0 | 9 |
| 6/30/00 | 41.7 | 1.22 | 2 | 36 | 0 | 9 |
| 7/1/00 | 41.7 | 1.22 | 2 | 38 | 0 | 9 |
| 7/2/00 | 41.7 | 1.22 | 2 | 40 | 0 | 9 |
| 7/3/00 | 37.5 | 1.20 | 1 | 41 | 0 | 9 |
| 7/4/00 | 35.4 | 1.19 | 0 | 41 | 0 | 9 |
| 7/5/00 | 37.5 | 1.20 | 0 | 41 | 0 | 9 |
| 7/6/00 | 37.5 | 1.20 | 0 | 41 | 0 | 9 |
| 7/7/00 | 37.5 | 1.20 | 0 | 41 | 0 | 9 |
| 7/8/00 | 37.5 | 1.20 | 0 | 41 | 0 | 9 |
| 7/9/00 | 37.5 | 1.20 | 0 | 41 | 0 | 9 |
| 7/10/00 | 33.6 | 1.18 | 1 | 42 | 0 | 9 |
| 7/11/00 | 33.6 | 1.18 | 0 | 42 | 0 | 9 |
| 7/12/00 | 33.6 | 1.18 | 0 | 42 | 1 | 10 |
| 7/13/00 | 25.8 | 1.14 | 0 | 42 | 0 | 10 |

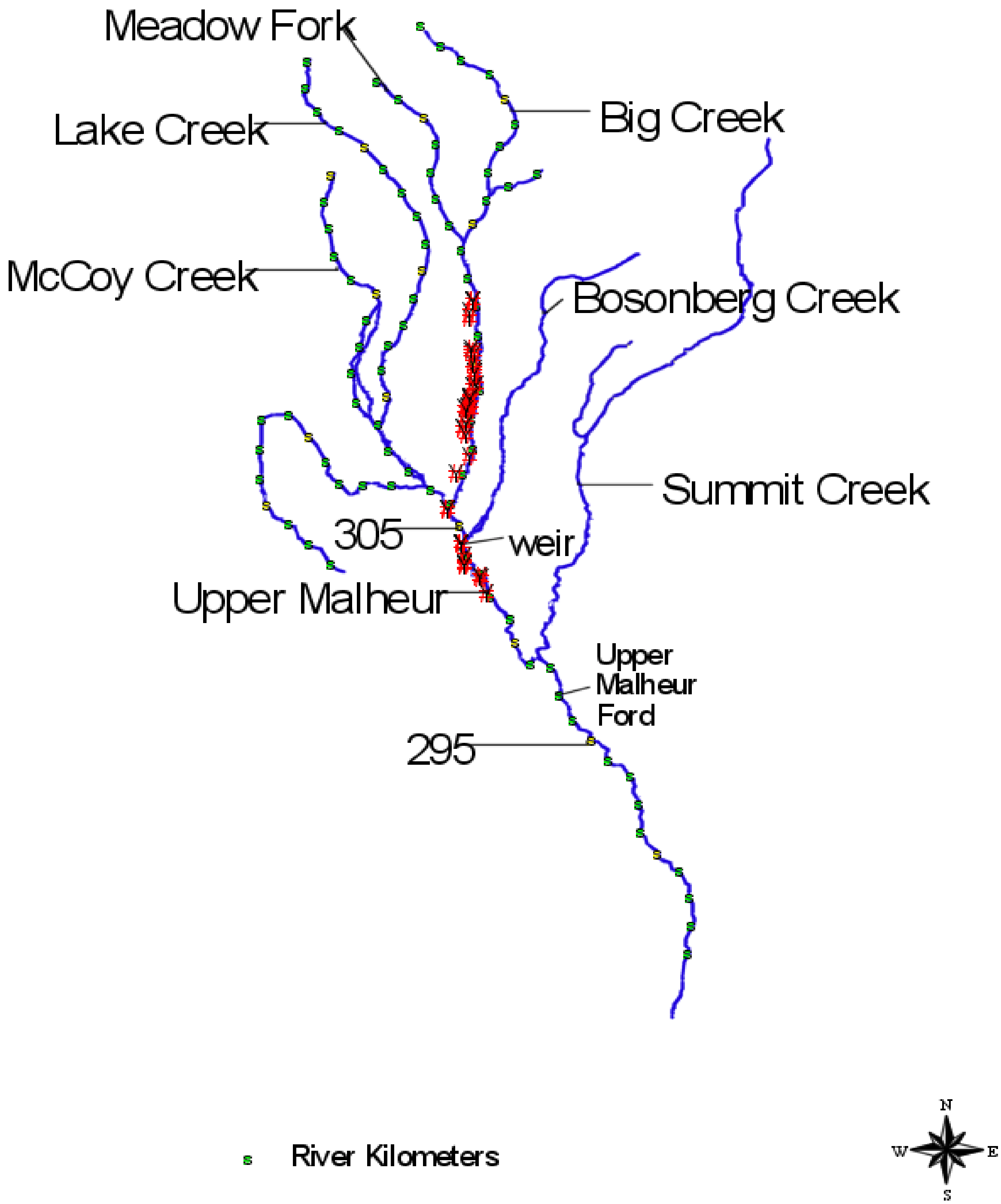
| | | | | | | |
|---|---|---|---|---|---|---|
| 7/14/00 | 25.8 | 1.14 | 0 | 42 | 0 | 10 |
| 7/15/00 | 25.8 | 1.14 | 1 | 43 | 0 | 10 |
| 7/16/00 | 25.8 | 1.14 | 0 | 43 | 0 | 10 |
| 7/17/00 | 25.8 | 1.14 | 2 | 45 | 0 | 10 |
| 7/18/00 | 25.8 | 1.14 | 0 | 45 | 2 | 12 |
| 7/19/00 | 25.8 | 1.14 | 0 | 45 | 0 | 12 |
| 7/20/00 | 25.5 | 1.12 | 0 | 45 | 0 | 12 |
| 7/21/00 | 25.3 | 1.10 | 0 | 45 | 0 | 12 |
| 7/22/00 | 25.5 | 1.12 | 1 | 46 | 0 | 12 |
| 7/23/00 | 25.2 | 1.09 | 1 | 47 | 0 | 12 |
| 7/24/00 | 25.2 | 1.09 | 0 | 47 | 0 | 12 |
| 7/25/00 | 25.4 | 1.09 | 0 | 47 | 0 | 12 |
| 7/26/00 | 25.7 | 1.09 | 1 | 48 | 0 | 12 |
| 7/27/00 | 25.9 | 1.09 | 1 | 49 | 0 | 12 |
| 7/28/00 | 26.1 | 1.09 | 0 | 49 | 0 | 12 |
| 7/29/00 | 24.7 | 1.08 | 0 | 49 | 0 | 12 |
| 7/30/00 | 23.4 | 1.07 | 0 | 49 | 0 | 12 |
| 7/31/00 | 24.7 | 1.08 | 1 | 50 | 0 | 12 |
| 8/1/00 | 24.7 | 1.08 | 0 | 50 | 0 | 12 |
| 8/2/00 | 24.7 | 1.08 | 1 | 51 | 0 | 12 |
| 8/3/00 | 23.4 | 1.07 | 0 | 51 | 0 | 12 |
| 8/4/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |
| 8/5/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |
| 8/6/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |
| 8/7/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |
| 8/8/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |
| 8/9/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |
| 8/10/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |
| 8/11/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |
| 8/12/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |
| 8/13/00 | 19.3 | 1.04 | 0 | 51 | 0 | 12 |
| 8/14/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |
| 8/15/00 | 23.4 | 1.07 | 0 | 51 | 0 | 12 |
| 8/16/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |
| 8/17/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |
| 8/18/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |
| 8/19/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |
| 8/20/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |
| 8/21/00 | 24.7 | 1.08 | 0 | 51 | 0 | 12 |
| 8/22/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |
| 8/23/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |
| 8/24/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |
| 8/25/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |
| 8/26/00 | 20.6 | 1.05 | 0 | 51 | 0 | 12 |
| 8/27/00 | 20.6 | 1.05 | 0 | 51 | 0 | 12 |
| 8/28/00 | 19.3 | 1.04 | 0 | 51 | 0 | 12 |
| 8/29/00 | 20.0 | 0.00 | 0 | 51 | 0 | 12 |
| 8/30/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 8/31/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |
| 9/1/00 | 22.0 | 1.06 | 0 | 51 | 0 | 12 |
| 9/2/00 | 24.7 | 1.08 | 0 | 51 | 0 | 12 |
| 9/3/00 | 25.3 | 1.10 | 0 | 51 | 0 | 12 |
| 9/4/00 | 24.7 | 1.08 | 0 | 51 | 0 | 12 |
| 9/5/00 | 24.7 | 1.08 | 0 | 51 | 0 | 12 |
| 9/6/00 | 24.7 | 1.08 | 0 | 51 | 0 | 12 |
| 9/7/00 | 24.7 | 1.08 | 0 | 51 | 0 | 12 |
| 9/8/00 | 23.7 | 1.07 | 0 | 51 | 0 | 12 |
| 9/9/00 | 24.7 | 1.08 | 0 | 51 | 0 | 12 |
| 9/10/00 | 23.7 | 1.07 | 0 | 51 | 0 | 12 |
| 9/11/00 | 24.7 | 1.08 | 0 | 51 | 0 | 12 |
| 9/12/00 | 24.7 | 1.08 | 0 | 51 | 0 | 12 |
| 9/13/00 | 24.7 | 1.08 | 0 | 51 | 0 | 12 |
| 9/14/00 | 24.7 | 1.08 | 0 | 51 | 0 | 12 |
| 9/15/00 | 24.7 | 1.08 | 0 | 51 | 0 | 12 |
| 9/16/00 | 24.7 | 1.08 | 0 | 51 | 0 | 12 |
| 9/17/00 | 24.7 | 1.08 | 0 | 51 | 0 | 12 |
| 9/18/00 | 24.7 | 0.00 | 0 | 51 | 0 | 12 |
| 9/19/00 | 24.7 | 1.08 | 0 | 51 | 0 | 12 |
| 9/20/00 | 24.7 | 1.08 | 0 | 51 | 0 | 12 |
| 9/21/00 | 24.7 | 1.08 | 0 | 51 | 0 | 12 |
| 9/22/00 | 24.7 | 1.08 | 0 | 51 | 0 | 12 |
| 9/23/00 | 24.7 | 1.08 | 0 | 51 | 0 | 12 |
| 9/24/00 | 24.7 | 1.09 | 0 | 51 | 0 | 12 |
| 9/25/00 | 24.7 | 1.08 | 0 | 51 | 1 | 13 |
| 9/26/00 | 24.7 | 1.08 | 0 | 51 | 0 | 13 |
| 9/27/00 | 24.7 | 1.08 | 0 | 51 | 0 | 13 |
| 9/28/00 | 23.7 | 1.07 | 0 | 51 | 0 | 13 |
| 9/29/00 | 24.7 | 1.08 | 0 | 51 | 0 | 13 |
| 9/30/00 | 24.7 | 1.08 | 0 | 51 | 0 | 13 |
| 10/1/00 | 24.7 | 1.08 | 0 | 51 | 0 | 13 |
| 10/2/00 | 24.7 | 1.08 | 0 | 51 | 0 | 13 |
| 10/3/00 | 24.7 | 1.08 | 0 | 51 | 0 | 13 |
| 10/4/00 | 24.7 | 1.08 | 0 | 51 | 0 | 13 |
| 10/5/00 | 24.7 | 1.08 | 0 | 51 | 0 | 13 |
| 10/6/00 | 24.7 | 1.08 | 0 | 51 | 0 | 13 |
| 10/7/00 | 26.1 | 1.09 | 0 | 51 | 2 | 15 |
| 10/8/00 | 26.1 | 1.09 | 0 | 51 | 0 | 15 |
| 10/9/00 | 33.5 | 1.17 | 0 | 51 | 0 | 15 |
| 10/10/00 | 25.5 | 1.12 | 0 | 51 | 0 | 15 |
| 10/11/00 | 24.7 | 1.09 | 0 | 51 | 0 | 15 |
| 10/12/00 | 25.5 | 1.12 | 0 | 51 | 0 | 15 |
| 10/13/00 | 25.5 | 1.12 | 0 | 51 | 0 | 15 |
| 10/14/00 | 25.5 | 1.12 | 0 | 51 | 0 | 15 |
| 10/15/00 | 25.5 | 1.12 | 0 | 51 | 0 | 15 |
| 10/16/00 | 25.5 | 1.12 | 0 | 51 | 0 | 15 |
| 10/17/00 | 25.3 | 1.10 | 0 | 51 | 0 | 15 |

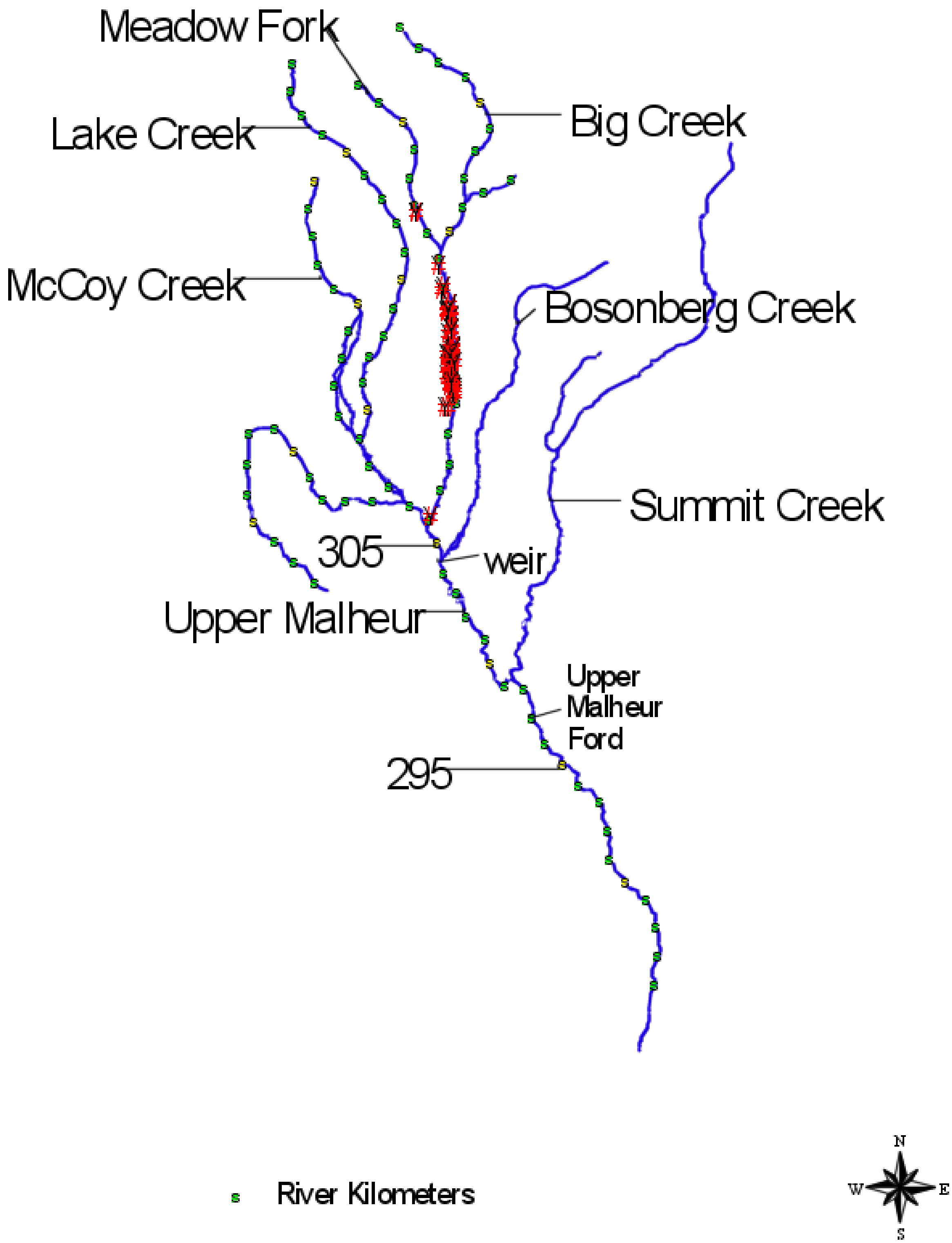
| | | | | | | |
|---|---|---|---|---|---|---|
| 10/18/00 | 25.3 | 1.10 | 0 | 51 | 0 | 15 |
| 10/19/00 | 25.3 | 1.10 | 0 | 51 | 0 | 15 |
| 10/20/00 | 25.3 | 1.10 | 0 | 51 | 0 | 15 |
| 10/21/00 | 25.8 | 1.14 | 0 | 51 | 0 | 15 |

**Appendix B.**
**Monthly Telemetery Observations For Bull Trout**

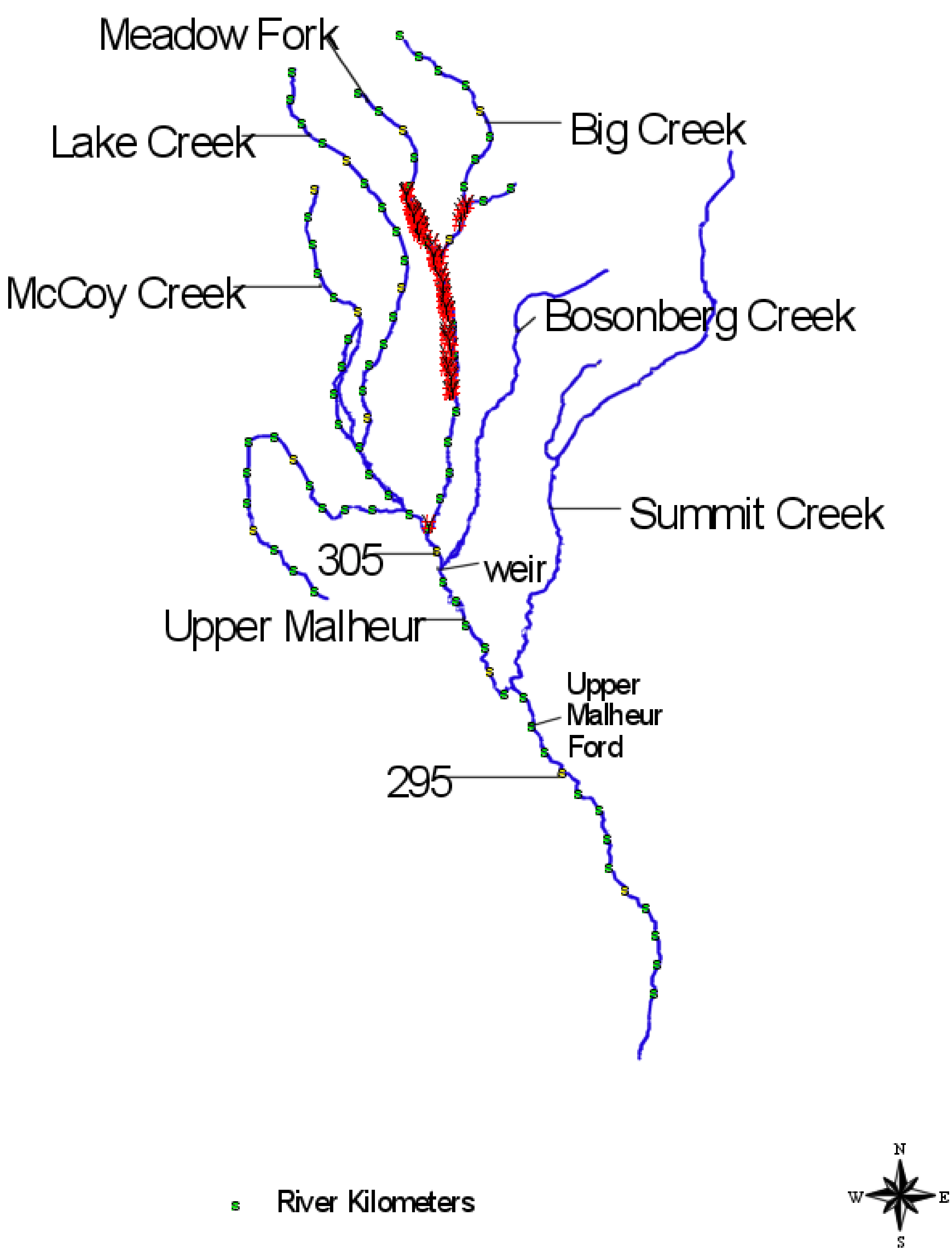
# June 2000



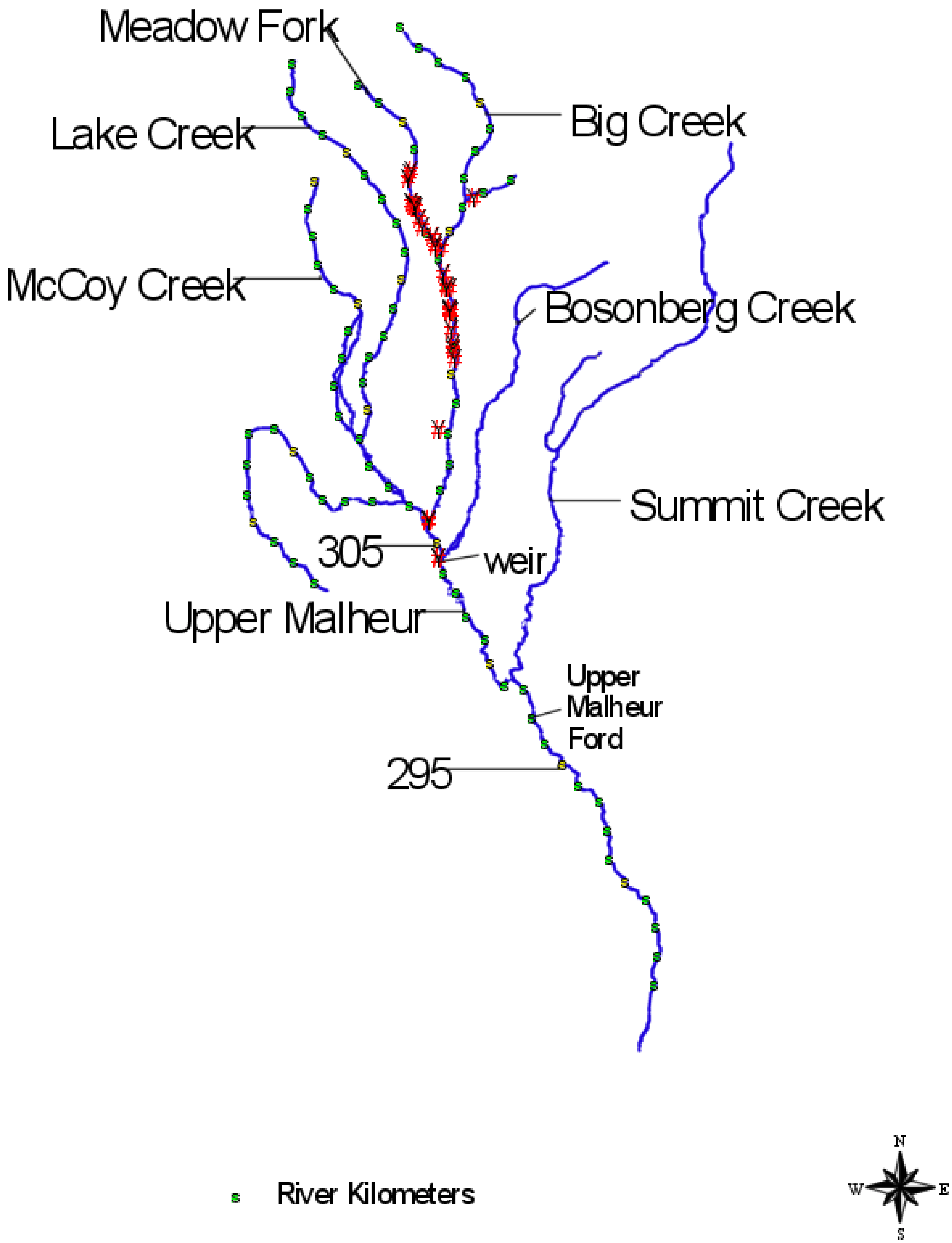
# July 2000


Meadow Fork
Big Creek
Lake Creek
McCoy Creek
Bosonberg Creek
Summit Creek
305
weir
Upper Malheur
Upper
Malheur
Ford
295
River Kilometers
N
W
E
S

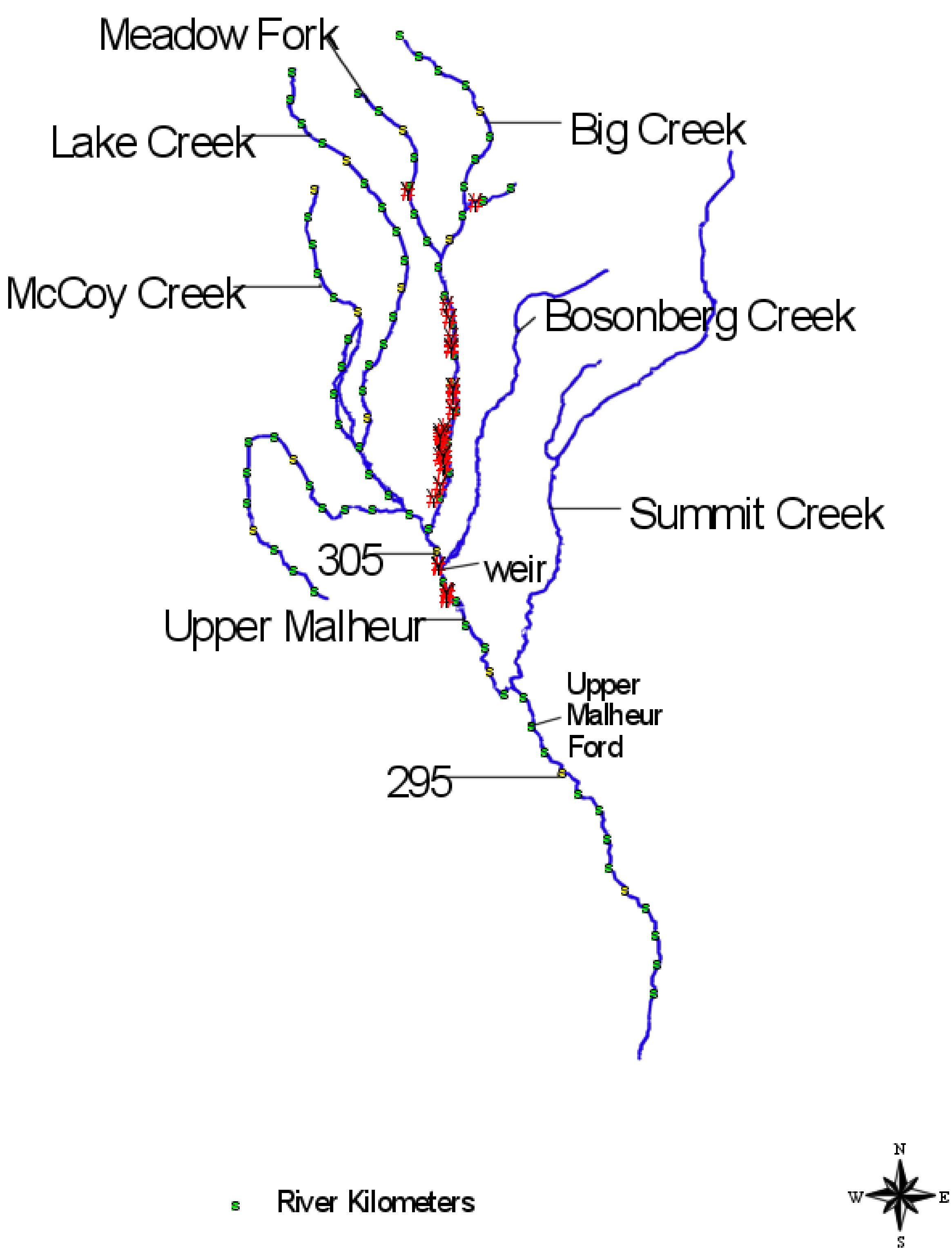
# August 2000


Meadow Fork
Lake Creek
Big Creek
McCoy Creek
Bosonberg Creek
Summit Creek
305
weir
Upper Malheur
Upper Malheur Ford
295
River Kilometers
N
W
E
S

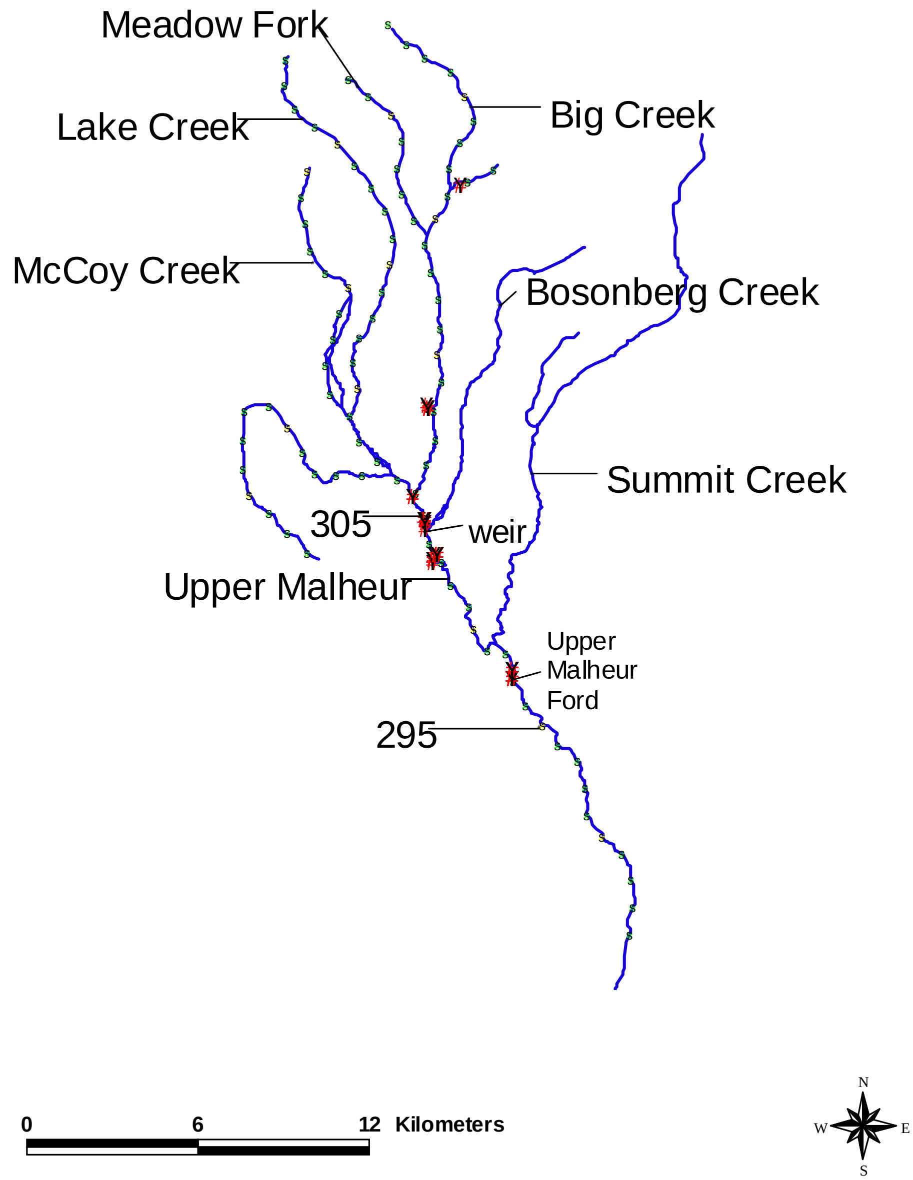
# September 2000



# October 2000



**November 2000**



# Bull Trout Spawning Survey Report, 2000
## Malheur Fish District

**Bill Tinniswood and Ray Perkins**

**April 24, 2001**

### INTRODUCTION

Bull trout (*Salvelinus confluentus*) spawning surveys by ODFW began in 1992. There are four main objectives for this study. The first three objectives apply to both watersheds. Objectives one, two, and three were to determine timing, location, and numbers of spawning bull trout. Objective four applies specifically to the upper Malheur River watershed. It was to try and determine timing and location of brook trout spawning.

### METHODS

Spawning surveys were completed on streams in the Upper Malheur and North Fork Malheur watershed streams known or suspected to support bull trout populations. Streams were surveyed from 29-31 August, 12-14 September, and 26-28 September. A fourth spawning survey was completed on streams in the Upper Malheur River watershed on 11-12 October.

Two or more people surveyed stream sections in an upstream direction. There was at least one experienced surveyor per team. Usually one member of each team walked on each side of the stream. Each crew used a GPS unit to record coordinates at the start and end of each stream section, redds, brook trout, and positively identified bull trout. Each GPS unit was set to record coordinates in decimal degrees or decimal minutes and the datum to NAD 1983. All redds, except for the last survey, were flagged for future reference and marked on a 7.5' quadrangle map. The estimated size (inches) of each bull trout positively identified was recorded. All GPS coordinates were entered into Arcview 3.1 and mapped.

## RESULTS

### North Fork Malheur River Watershed

#### North Fork Malheur River

The upper North Fork Malheur was surveyed three times in 2000. The survey began at the mouth of Deadhorse Creek and ended 3.5 miles upstream at the headwater spring (Appendix Figure A-1). Six redds and two bull trout were observed on 29 August, ten redds and no bull trout were observed on 12 September, and no redds and four bull trout were observed on 26 September (Table 1).

Table 1. Bull trout redds observed in the mainstem of the North Fork Malheur River.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1992[a] | 1 | 5.9 | 0.2 |
| 1993 | 1 | 15.5 | 0.1 |
| 1994 | 0 | 7.3 | 0.0 |
| 1995 | 0 | 6.0 | 0.0 |
| 1996 | 6 | 3.9 | 1.5 |
| 1997 | 10 | 2.3 | 4.4 |
| 1998 | 3 | 3.8 | 0.8 |
| 1999 | 9 | 3.5 | 2.6 |
| 2000 | 16 | 3.5 | 4.3 |

[a]- Does not include 14 questionable redds observed by volunteers included in earlier reports.

### Horseshoe Creek

Horseshoe Creek was surveyed three times in 2000. The survey began at its confluence of North Fork Malheur River and ended about 0.8 miles upstream (Appendix Figure A-1). Four redds and five bull trout were observed on 29 August, three redds and no bull trout were observed on 12 September, and no redds or bull trout were observed on 26 September (Table 2).

Table 2. Bull trout redds observed in Horseshoe Creek, tributary to North Fork Malheur River.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1998 | 4 | 0.4 | 10.0 |
| 1999 | 4 | 0.8 | 5.0 |
| 2000 | 7 | 0.8 | 6.3 |

#### Deadhorse Creek

Deadhorse Creek was surveyed twice in 2000. The survey began at its confluence of North Fork Malheur River and ended about 0.8 miles upstream (Appendix Figure A-1). No redds or bull trout were observed on 12 and 24 September (Table 3). No redds or bull trout were observed in 1999.

Table 3. Bull trout redds observed in Deadhorse Creek, tributary to North Fork Malheur River.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1999 | 0 | 0.8 | 0.0 |
| 2000 | 0 | 0.8 | 0.0 |

### Flat Creek

Flat Creek was not surveyed this year.

### Swamp Creek

Upper Swamp Creek was surveyed three times in 2000 (Appendix Figure A-2). Eight redds and 16 bull trout were observed on 29 August, twenty-one redds and 39 bull trout were observed on 12 September, and six redds and 12 bull trout were observed on 26 September (Table 4). Lower Swamp was surveyed three times in 2000 (Appendix Figure A-2). Five redds and one bull trout were observed on 29 August. No redds and four bull trout were observed on 12 September, and no redds or bull trout or were observed on 26 September (Table 4).

Table 4. Bull trout redds observed in Swamp Creek, tributary to North Fork Malheur River.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1992 | 0 | 1.2 | 0.0 |
| 1993 | 3 | 2.2 | 1.4 |
| 1994 | 9 | 3.9 | 2.3 |
| 1995 | 0 | 3.9 | 0.0 |
| 1996 | 8 | 3.8 | 2.1 |
| 1997 | 21 | 4.1 | 5.1 |
| 1998 | 24 | 4.2 | 5.7 |
| 1999 | 35 | 4.1 | 8.5 |
| 2000 | 40 | 4.1 | 9.8 |

## Sheep Creek

The Sheep Creek survey was divided into two sections. The lower survey began at the mouth and ended about two miles upstream. The upper section began at the two-mile mark and ended near the 4-mile mark. Upper Sheep Creek was surveyed three times in 2000 (Appendix Figure A-2). One redd and three bull trout were observed on 29 August, five bull trout and no redds were observed on 12 September, and one redd and no bull trout were observed on the 26 September (Table 5). Lower Sheep Creek was surveyed three times in 2000 (Appendix Figure A-2). Nine redds and 12 bull trout were recorded on 29 August, nine redds and 14 bull trout were observed on 12 September, and five redds and seven bull trout were observed on 27 September (Table 5).

Table 5. Bull trout redds observed in Sheep Creek, tributary to North Fork Malheur River.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1992 | 0 | 1.1 | 0.0 |
| 1993 | 0 | 2.2 | 0.0 |
| 1994 | 0 | 2.2 | 0.0 |
| 1995 | 2 | 2.9 | 0.7 |
| 1996 | 13 | 3.4 | 3.8 |
| 1997 | 8 | 2.9 | 2.8 |
| 1998 | 17 | 3.5 | 4.9 |
| 1999 | 22 | 3.0 | 7.3 |
| 2000 | 25 | 4.0 | 6.3 |

**Elk Creek**

Elk Creek was surveyed three times in 2000 (Appendix Figure A-3). The lower section started at the confluence with North Fork Malheur River and ended at North Fork and South Fork confluence. Three redds and five bull trout were observed on 30 August, no redds and six bull trout were observed on 13 September, and no redds or bull trout were observed on 28 September (Table 6). North Fork Elk Creek was surveyed three times in 2000. This section began at the confluence of the North and South Forks and ended upstream about 1 mile. No redds or bull trout were observed on 30 August, two redds and eleven bull trout were observed on 13 September, and no redds or bull trout were observed on 28 September (Table 6). South Fork Elk Creek was surveyed three times in 2000. This section began at the confluence of the North and South forks and ended upstream about ¼ mile. No redds or bull trout were observed on 30 August, no redds and two bull trout were observed on 13 September, and no bull trout or redds were observed on 28 September (Table 6).

Table 6. Bull trout redds observed in mainstem Elk Creek and North and South Forks, tributary to North Fork Malheur River.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1992 | 1 | 1.0 | 1.0 |
| 1993 | 1 | 2.3 | 0.4 |
| 1994 | 0 | 2.0 | 0.0 |
| 1995 | 1 | 4.0 | 0.3 |
| 1996 | 3 | 4.1 | 0.7 |
| 1997 | 9 | 4.1 | 2.2 |
| 1998 | 6 | 3.5 | 1.7 |
| 1999 | 12 | 3.0 | 4.0 |
| 2000 | 5 | 3.0 | 1.7 |

**Crane Creek**

Crane Creek was not surveyed this year.

**Little Crane Creek**

Upper Little Crane Creek was surveyed five times in 2000 (Appendix Figure A-4). This section starts at the 16 road and ends about two miles upstream at the 1665-0498 road. This stream section was surveyed each day during the first week of surveys. This is done to try and determine how much time it takes to build a redd, how many redds a spawning pair would dig, and movement and pairing differences between days. Thirteen redds and forty-four bull trout were observed on 29 August, seven additional redds were observed on the 30 August, another nine redds were observed on 31 August. Twenty new redds and 37 bull trout were observed on 12 September. Ten redds and nine bull trout were observed on 26 September (Table 7). Cattle use was observed on Little Crane Creek during the survey. Lower Little Crane Creek was surveyed three times in 2000 (Appendix Figure A-5). The section begins at the confluence of Little Crane and Crane creeks and ends at Forest Road 16. No redds and five bull trout were observed on 30 August, no redds and four bull trout were observed on 13 September, and one redd and no bull trout were observed on 26 September (Table 7).

Table 7. Bull trout redds observed in Little Crane Creek, tributary to North Fork Malheur.

| YEAR | **REDDS** | **MILES** | **REDDS/MILE** |
|---|---|---|---|
| 1992 | | | |
| 1993 | 3 | 5.6 | 0.5 |
| 1994 | 4 | 7.5 | 0.5 |
| 1995 | 6 | 6.0 | 1.0 |
| 1996 | 8 | 6.0 | 1.3 |
| 1997 | 16 | 4.2 | 3.8 |
| 1998 | 20 | 6.0 | 3.3 |
| 1999 | 33 | 6.1 | 5.4 |
| 2000 | 60 | 6.1 | 9.8 |

**Cow Creek**

Cow Creek was surveyed twice in 2000 (Appendix Figure A-2). This section began at the confluence of Cow Creek and the North Fork Malheur River and ended about one mile upstream. No redds and four bull trout were observed on 29 August and no redds and one bull trout was observed on 13 September.

**Little Cow Creek**

Little Cow Creek was surveyed twice in 2000 (Appendix Figure A-2). This section began at its confluence with Cow Creek and ended about ½ mile upstream. No redds or bull trout were observed on the 29 August or 13 September.

### Bull Trout Observations

Beginning in 1999 frequency, size and location of bull trout was documented (Appendix Figure C-2). The number of bull trout observed during the surveys increased this year (Table 8). As in 1999, larger bull trout were observed on the 29-31 August survey. In the North Fork Malheur and upper Malheur watersheds 41 bull trout greater than 305mm length were observed in 2000.

Table 8. Average lengths (inches) and frequency of bull trout observed during spawning surveys on the North Fork Malheur River Watershed 29 August – 28 September.

| STREAM | YEAR | 1ST PASS | | 2ND PASS | | 3RD PASS | | TOTAL |
|---|---|---|---|---|---|---|---|---|
| | | N | FL | N | FL | N | FL | |
| Swamp Cr. | 1999 | 25 | 11” | 23 | 10” | 0 | | 48 |
| | 2000 | 14 | 12” | 43 | 9” | 12 | 9’ | 66 |
| L. Crane Cr. | 1999 | 37 | 10” | 39 | 8” | 19 | 8” | 95 |
| | 2000 | 75 | 10” | 41 | 9” | 9 | NA | 94 |
| Sheep Cr. | 1999 | 24 | 8” | 11 | 9” | 8 | 10” | 43 |
| | 2000 | 15 | 10” | 19 | 10” | 7 | 8” | 41 |
| Elk Cr. | 1999 | 10 | 10” | 5 | 10” | 3 | 10” | 18 |
| | 2000 | 5 | 11” | 18 | 8” | 0 | | 24 |
| Upper North Fork | 1999 | 11 | 13” | 3 | 8” | 0 | | 14 |
| | 2000 | 7 | 12” | 0 | | 4 | 9” | 11 |
| Cow Cr. | 2000 | 4 | 5” | 1 | 5” | 0 | | 5 |
| **Total** | **1999** | **107** | | **81** | | **30** | | **218** |
| **Total** | **2000** | **120** | | **122** | | **32** | | **274** |

### Bull Trout Observed On Redds

A total of 44 or 29%(44/151) of redds were observed with bull trout. Redds were observed with up to five bull trout. Fifteen, twenty-two, four, two, and one redds were observed with one, two, three, four and five bull trout, respectively. Which converts into about 2.4 bull trout per redd.

## Upper Malheur River Watershed

### Summit Creek

Upper Summit Creek was surveyed four times in 2000 (Appendix Figure B-1). This section began at private property boundary and ended upstream about 2.3 miles. Two redds and no bull trout were observed on 30 August, eight redds and no bull trout were observed on 14 September, and thirty-three redds and no bull trout were observed on 27 September (Table 9). Forty-three redds and one bull trout were observed on 11 October. Middle Summit Creek was surveyed twice in 2000. The section began at the 1651 road and ended about 2.5 miles upstream at the forest boundary downstream of the prairie. No bull trout or redds were observed on 30 August and 28 September.

Table 9. Redds observed in Summit Creek, tributary to Upper Malheur River.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1999 | 18 | 2.3 | 7.8 |
| 2000 | 43 | 4.8 | 9.0 |

### Snowshoe Creek

Snowshoe Creek was surveyed three times in 2000 (Appendix Figure B-2). The section began at the confluence of Snowshoe and Big creeks and ended about 1.7 miles upstream. No redds or bull trout were observed on 31 August, three redds and no bull trout were observed on 13 September, and no redds and one bull trout were observed on 28 September (Table 10).

Table 10. Redds observed in Snowshoe Creek, tributary to Big Creek.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1998 | 10 | 1.7 | 5.9 |
| 1999 | 25 | 1.7 | 14.7 |
| 2000 | 3 | 1.7 | 1.8 |

### Big Creek

Lower Big Creek was surveyed four times in 2000 (Appendix Figure B-3). The section began at the 16 road and ended at the 1648 road. No redds or bull trout were observed on 30 August, four redds and one bull trout were observed on 14 September, and eighteen redds and one bull trout were observed on 28 September (Table 11). Nineteen redds and no bull trout were observed on 12 October. Upper Big Creek was surveyed three times in 2000 (Appendix Figure B-3). The section began at the 1648 road and ended at the confluence with Snowshoe Creek. No redds or bull trout were observed on 30 August or 28 September, while no redds and one bull trout was observed on 13 September (Table 11).

Table 11. Redds observed in Big Creek, tributary to Upper Malheur River.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1998 | 0 | 2.3 | 0.0 |
| 1999 | 8 | 4.6 | 1.7 |
| 2000 | 22 | 4.6 | 4.8 |

**Meadow Fork Big Creek**

Lower Meadow Fork was surveyed four times in 2000 (Appendix Figure B-4). The section began at the confluence with Big Creek and ended upstream at the trailhead. One redd and four bull trout were observed on 31 August, five redds and three bull trout on 14 September, and thirteen redds and no bull trout were observed on 27 September (Table 12). Three redds and no bull trout were observed on 12 October. Upper Meadow Fork was surveyed four times in 2000 (Appendix Figure B-4). The section began at the trailhead and ended upstream about 2 miles at the waterfall. Ten redds and seven bull trout were observed on 31 August, thirteen redds and eleven bull trout were observed on 13 September, and nine redds and six bull trout were observed on the 27 September (Table 12). Five redds and eleven bull trout were observed on 12 October.

Table 12. Redds observed in Meadow Fork Big Creek, tributary to Big Creek, from late August-late September.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1998 | 39 | 3.3 | 11.8 |
| 1999 | 25 | 3.3 | 7.6 |
| 2000 | 51 | 3.3 | 14.8 |

**Lake Creek**

Lower Lake Creek was surveyed three times in 2000 (Appendix Figure B-5). The section started at the 1648 road and ended at the trailhead. No redds or bull trout were observed on 29 August, one redd and two bull trout were observed on 14 September, and three redds were observed on 27 September (Table 12). Upper Lake Creek was surveyed four times in 2000 (Appendix Figure B-5). The section started at the trailhead and ended at an approximately 30-foot waterfall. Three redds and two bull trout were observed on 31 August, three redds and no bull trout were observed on 14 September, twelve redds and three bull trout were observed on 27 September (Table 13). Two redds and no bull trout were observed on 12 October (Table 13).

Table 13. Redds observed in Lake Creek, tributary to Upper Malheur River, from late August-late September, 1998-2000 Grant County, OR.

| YEAR | REDDS | MILES | REDDS/MILE |
|---|---|---|---|
| 1998 | 34 | 2.1 | 16.2 |
| 1999 | 21 | 4.3 | 4.9 |
| 2000 | 22 | 4.3 | 5.1 |

**Bosonberg Creek**

Bosonberg Creek was not surveyed this year. In 1999 Bosonberg Creek was surveyed twice and no redds or bull trout were observed.

### Fish Observed On Redds

A total of 38 or 27% (38/141) redds were observed with fish. Redds were observed with up to six brook trout and three bull trout. Fourteen and eighteen redds were observed with bull trout and brook trout, respectively (Appendix Figure C-1). Two redds were observed with one brook trout and a possible bull trout but a positive identification could not be made. Fish were seen on redds but could not be identified (Table 14). In this watershed there were 2.2 bull trout per redd, which is similar to the North Fork Malheur River number.

Table 14. Frequency of bull trout and brook trout observed on redds in the Upper Malheur River watershed from late August –early October 2000, Grant County, OR.

| | One Fish | Two Fish | Three Fish | Four Fish | Five fish | Six Fish | Unk. # Fish |
|---|---|---|---|---|---|---|---|
| Bull Trout | 9 | 4 | 1 | | | | |
| Brook Trout | 7 | 7 | 0 | 1 | 0 | 1 | 2 |
| Brook Trout and unknown fish | 0 | 2 | | | | | |
| Unknown fish | 3 | 1 | | | | | |

## DISCUSSION

North Fork Malheur redd counts for the years 1992-95 were influenced by inconsistent survey techniques between years. During those years project personnel were struggling with uncertainties related to spawning timing, and location. Consequently, there was variation in timing of surveys and areas surveyed. Livestock were also abundant in spawning areas during those years making identification of redds difficult. Since 1996, survey areas and timing have been standardized. Expertise of surveyors has also increased and all are familiar with each stream. A change in livestock management has reduced stream disturbance and made redds more easily identifiable.

Generally, most streams in the North Fork Malheur showed increases in redd counts. The mainstem North Fork Malheur, Swamp Creek, Sheep Creek, and Little Crane Creek had the highest redd counts since surveys started in 1992. Little Crane showed the highest increase in redd counts at almost two-fold. However, in 1997 North Fork Malheur had a higher redd per mile count than in 2000. Elk Creek showed a large decline in redds. More redds were observed in 1997-1999 than 2000 in Elk Creek. Cattle were present during all surveys on Elk Creek.

A total of 153 redds were observed in the North Fork Malheur basin in 2000 compared to 115 redds in 1999. Sixty redds were observed on Little Crane Creek this year compared to thirty-three in 1999. Little Crane Creek was also surveyed three days in succession to determine the length of time it requires bull trout to construct redds. New redds were observed on the second and third day suggesting bull trout construct redds in one day. It was not possible to identify individual bull trout on succeeding days to assist in determining movements or if a bull trout makes more than one redd.

Lower Sheep, Upper Swamp and Upper Little Crane Creek continue to be prime spawning areas for bull trout. Good spawning habitat seems to be concentrated in small areas of these three sites (Appendix Figure A-2). It is unknown if these areas are the only suitable spawning sites. Further research needs to be completed to get a better understanding of why bull trout spawn in these areas.

One bull trout (381mm) mortality was found on 28 September on Sheep Creek. Bull trout up to 635mm were observed on Swamp Creek. Most large bull trout were observed during the first spawning survey on the 29 August.

Cow and Little Cow Creek were surveyed for the first time this year. Only a few bull trout were observed.

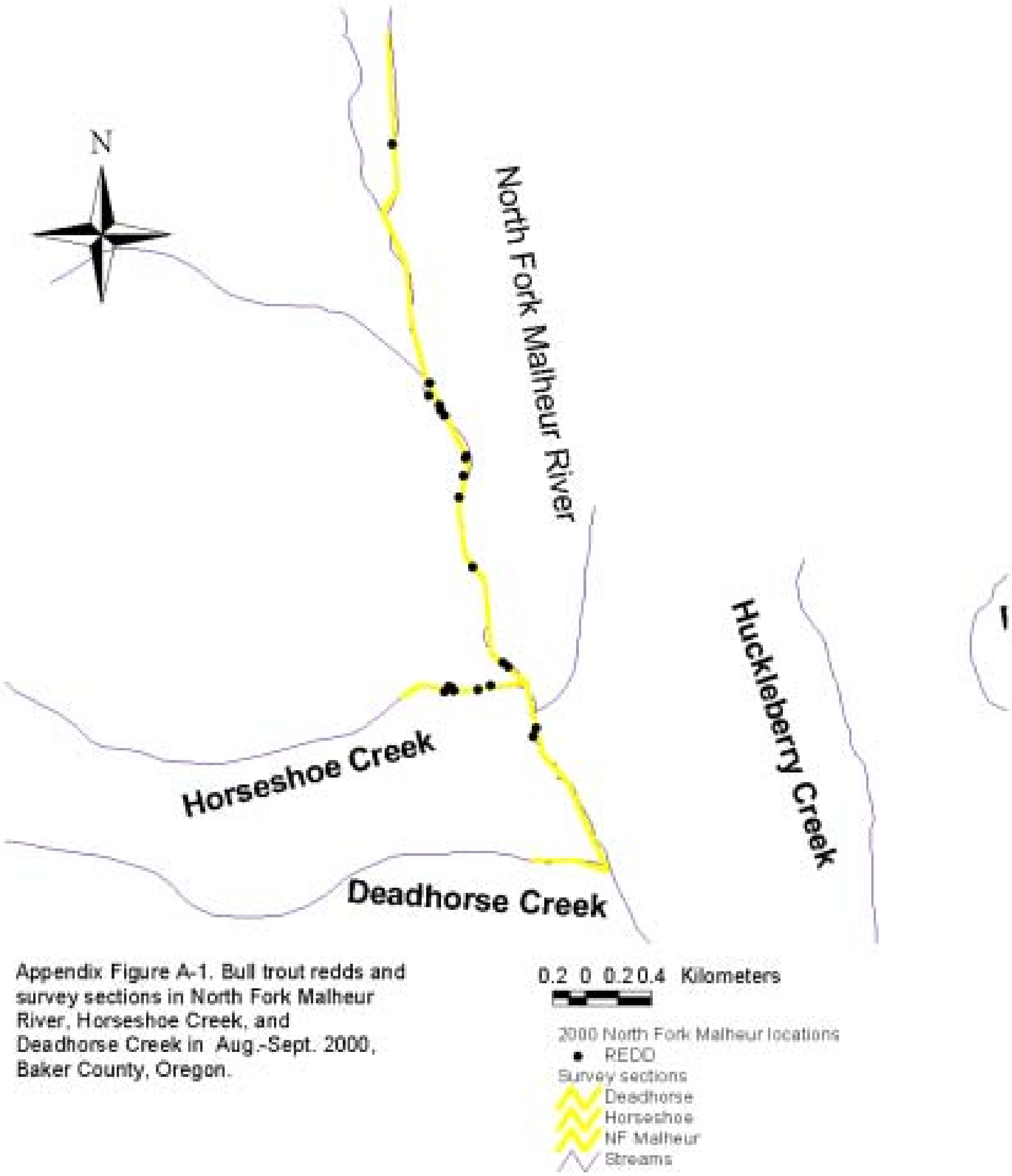
Redd counts in the Upper Malheur River Watershed also increased. A total of 141 redds were observed in the first three surveys in 2000 compared to 97 redds in 1999. Upper Summit, Big Creek, and Meadow Fork Big Creek had the highest redd counts since the surveys started in 1998. Upper Summit and Meadow Fork Big Creek showed a two-fold increase. Big Creek showed close to a three-fold increase in observed redds. Snowshoe showed a large decline in observed redds. Alder is becoming increasingly thick along Snowshoe Creek which is making observing redds more difficult than in past years. The change in streamside canopy is the result of ecological change from fire disturbance.

A total of 72 redds were observed on the fourth spawning survey in Upper Summit, Lower Big Creek, Upper and Lower Meadow Fork, and Upper Lake Creek. Number of redds on the fourth pass comprised almost 50% of the total observed in Lower Big Creek and Summit Creek. Very few bull trout were observed in either of these streams. The bull trout identified this year in Summit Creek is the first during spawning time and the first this high in the stream. If one assumes most of the redds on the fourth pass were made by brook trout, this suggests that peak spawning of brook trout in the Upper Malheur River Watershed occurs later than bull trout spawning. Upper Meadow Fork Creek is the only stream in the upper Malheur watershed where bull trout dominated the observations. New redds observed on Upper Meadow Fork Big Creek and the lack of brook trout observed infers low overlap between brook and bull trout spawning. Surprisingly, only two stream sections, Lower Big Creek and Upper Summit, had high brook trout redd counts while Upper Lake, Snowshoe, Lower Meadow Fork, and Upper Big Creek had very low redd counts. This might be beneficial in suppressing or eliminating brook trout in the Upper Malheur River Watershed.

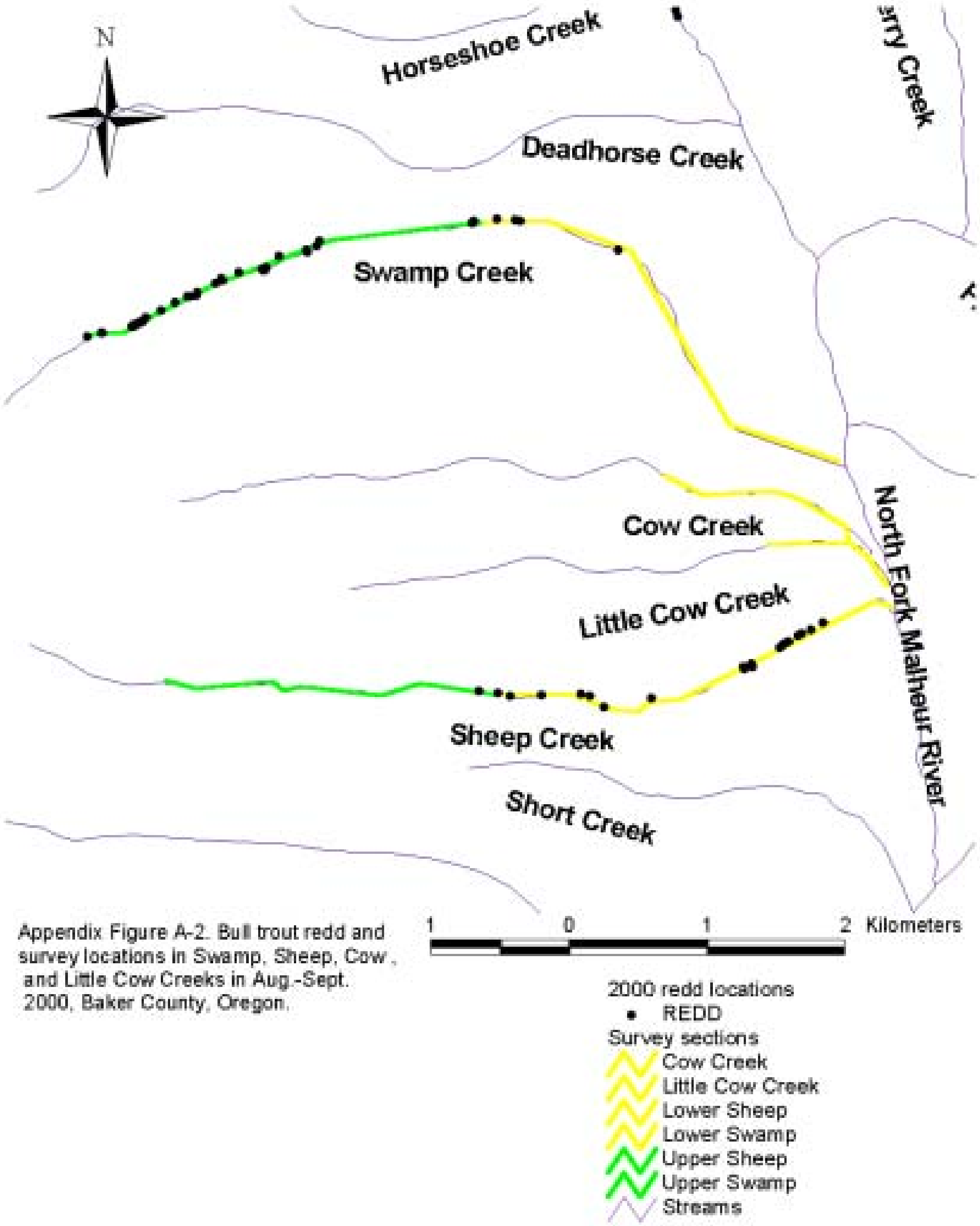
Excellent water years and the prohibited take of bull trout might be some reasons why redd counts have continued to increase since 1992. Increases in water levels have increased possible habitat in Beulah Reservoir and North Fork Malheur River. Recent aggressive riparian and cattle management has also contributed improved habitat for bull trout.  The increase in redds on Big Creek and Upper Summit Creek, both noted for having lots of brook trout, might suggest excellent water years are more responsible for an increase in the bull trout population than prohibited take.

**APPENDIX A**

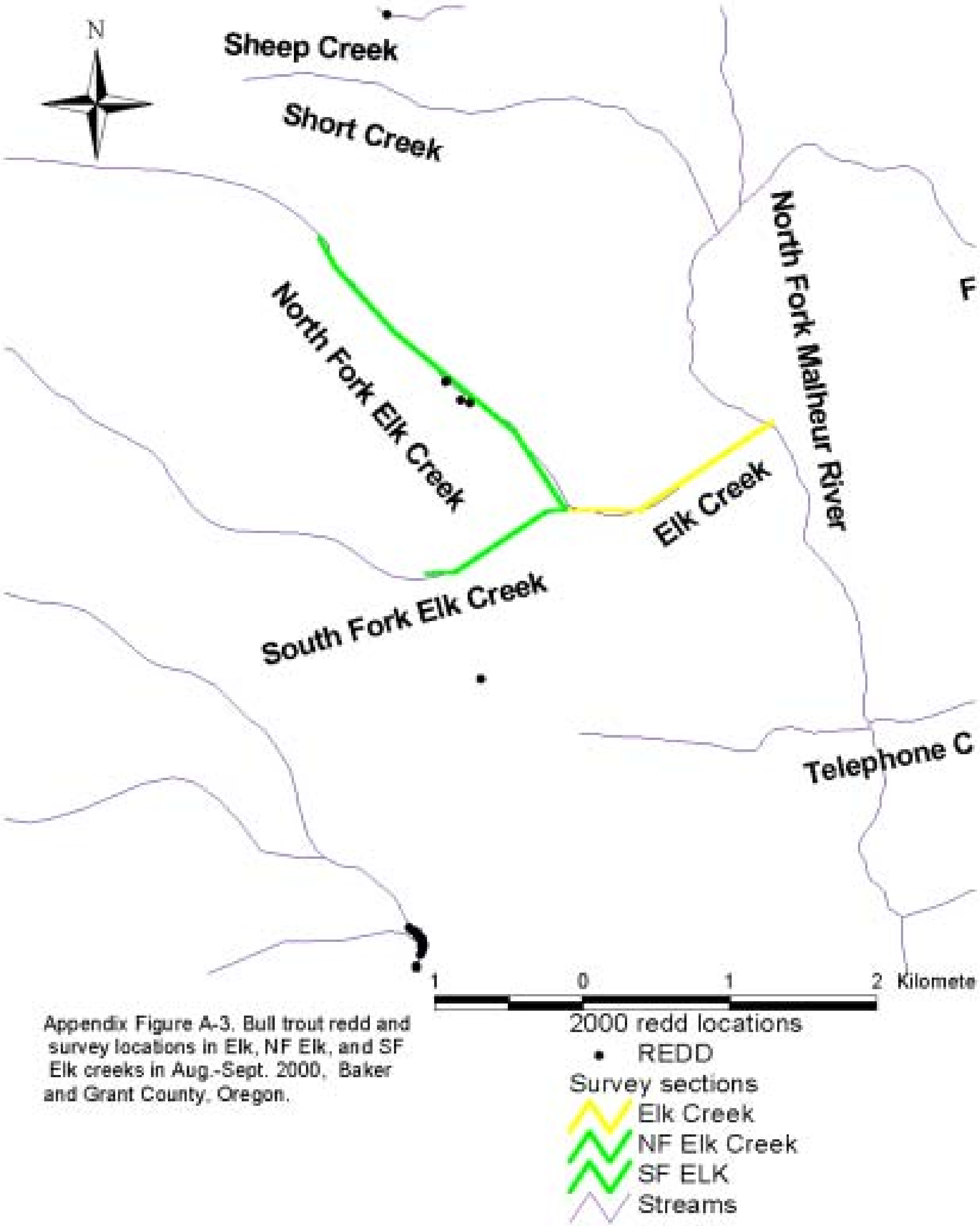
Locations of Bull Trout Redds Observed During Spawning Surveys in the North Fork Malheur Watershed in 2000, Baker and Grant Counties, Oregon



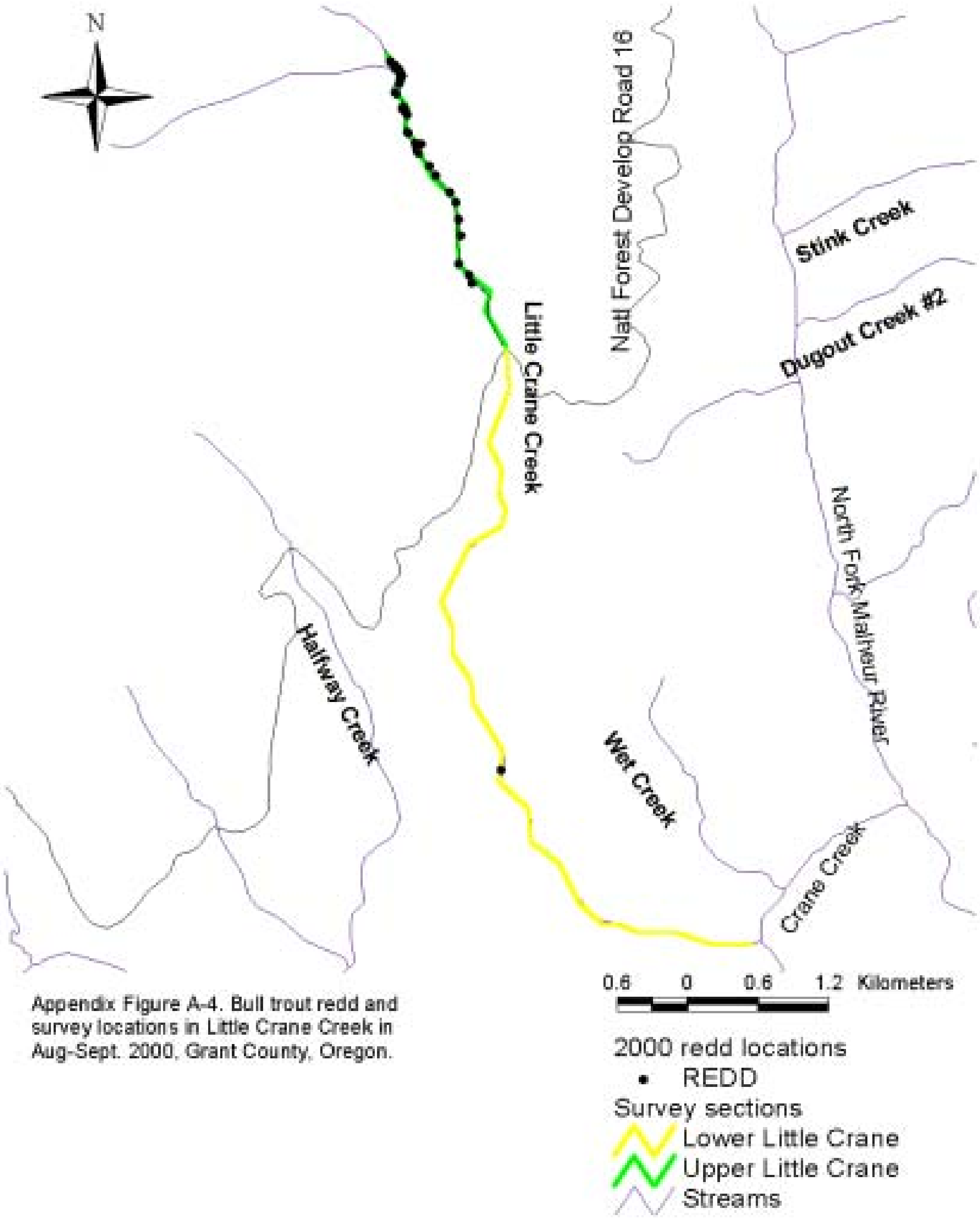

Appendix Figure A-1. Bull trout redds and survey sections in North Fork Malheur River, Horseshoe Creek, and Deadhorse Creek in Aug.-Sept. 2000, Baker County, Oregon.




Appendix Figure A-2. Bull trout redd and survey locations in Swamp, Sheep, Cow, and Little Cow Creeks in Aug.-Sept. 2000, Baker County, Oregon.



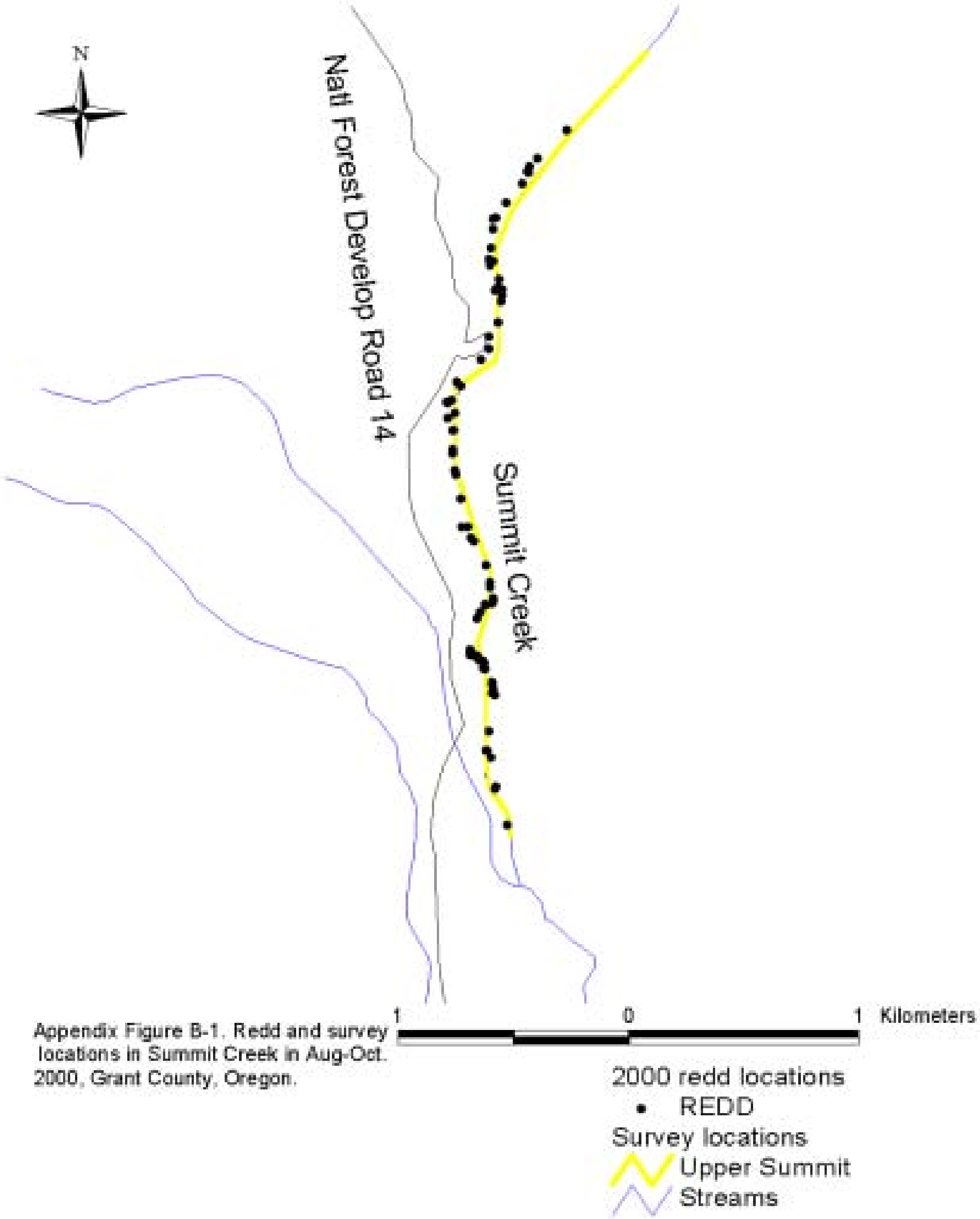

Appendix Figure A-3. Bull trout redd and survey locations in Elk, NF Elk, and SF Elk creeks in Aug.-Sept. 2000, Baker and Grant County, Oregon.



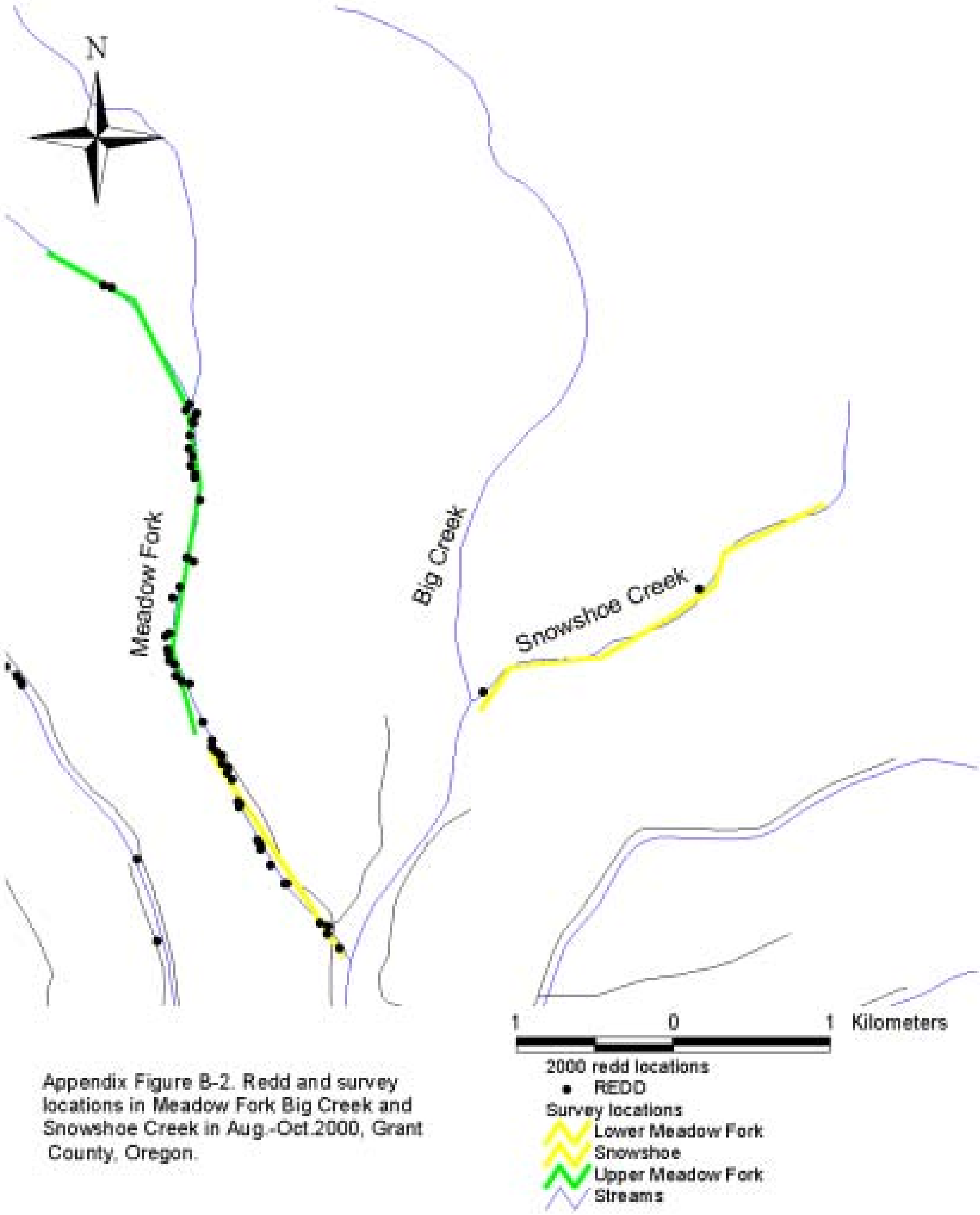

Appendix Figure A-4. Bull trout redd and survey locations in Little Crane Creek in Aug-Sept. 2000, Grant County, Oregon.

APPENDIX B

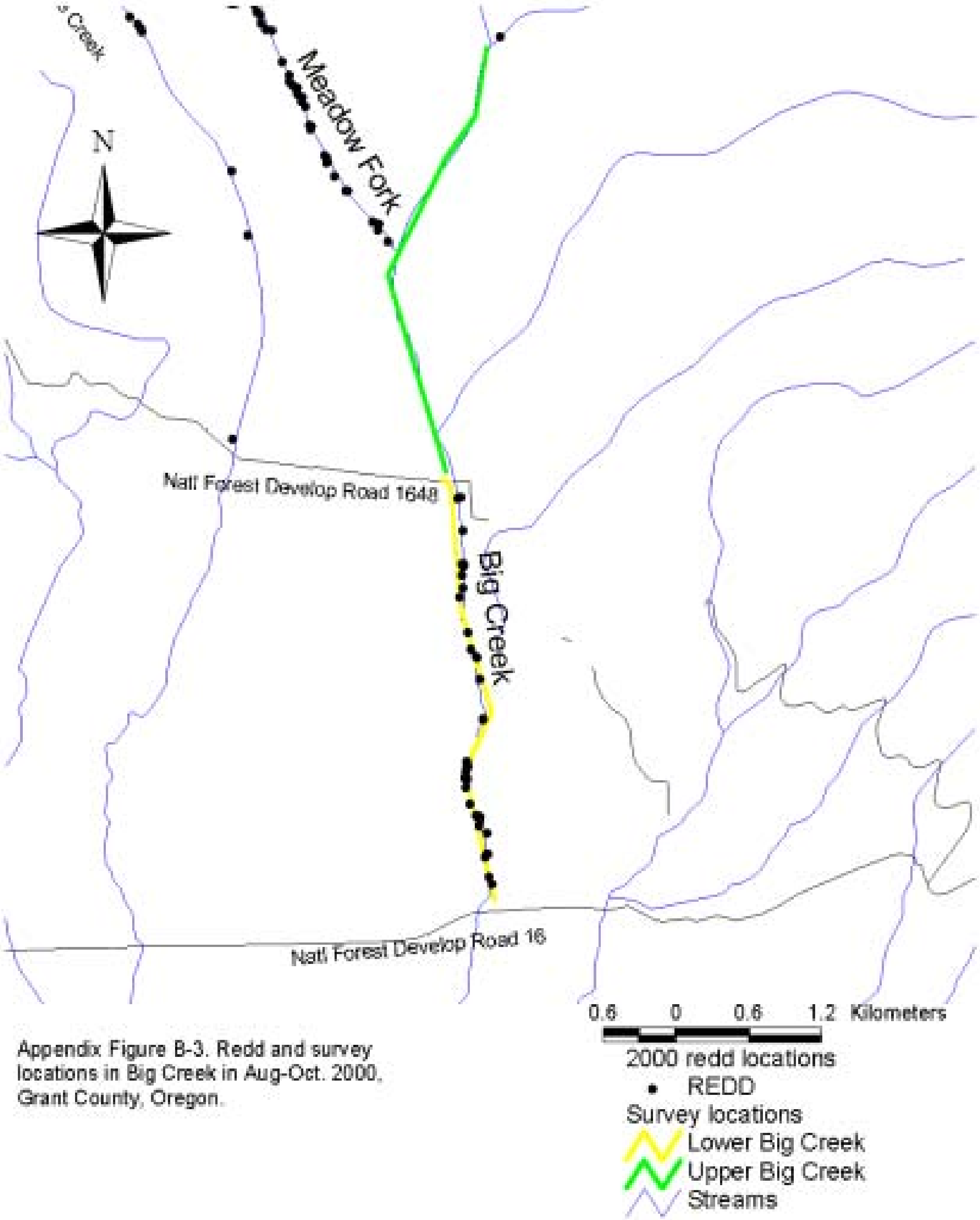
Locations of Redds in the Upper Malheur River Watershed in Aug-Oct. 2000, Baker County, Oregon.



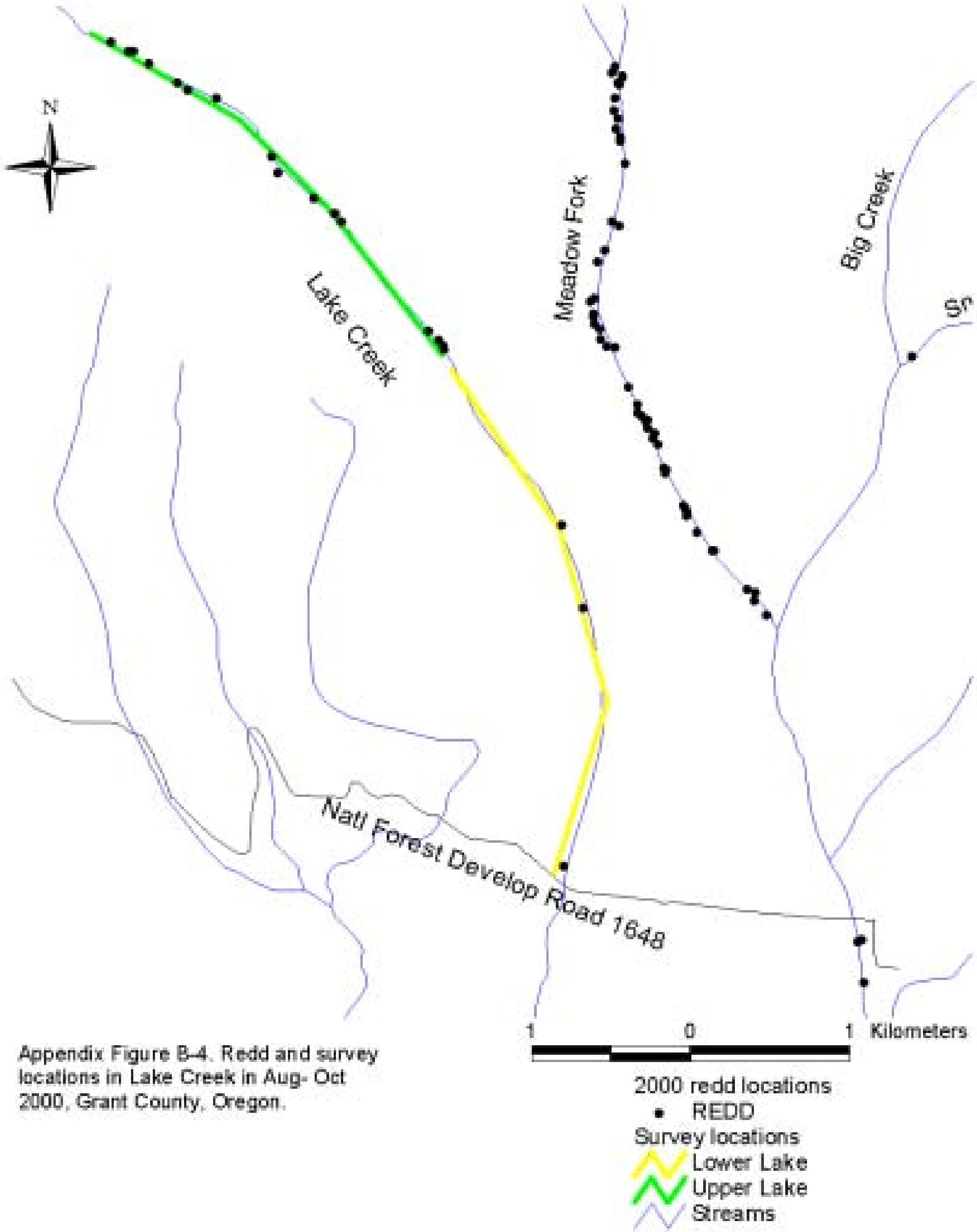

Appendix Figure B-1. Redd and survey locations in Summit Creek in Aug-Oct. 2000, Grant County, Oregon.




Appendix Figure B-2. Redd and survey locations in Meadow Fork Big Creek and Snowshoe Creek in Aug.-Oct.2000, Grant County, Oregon.



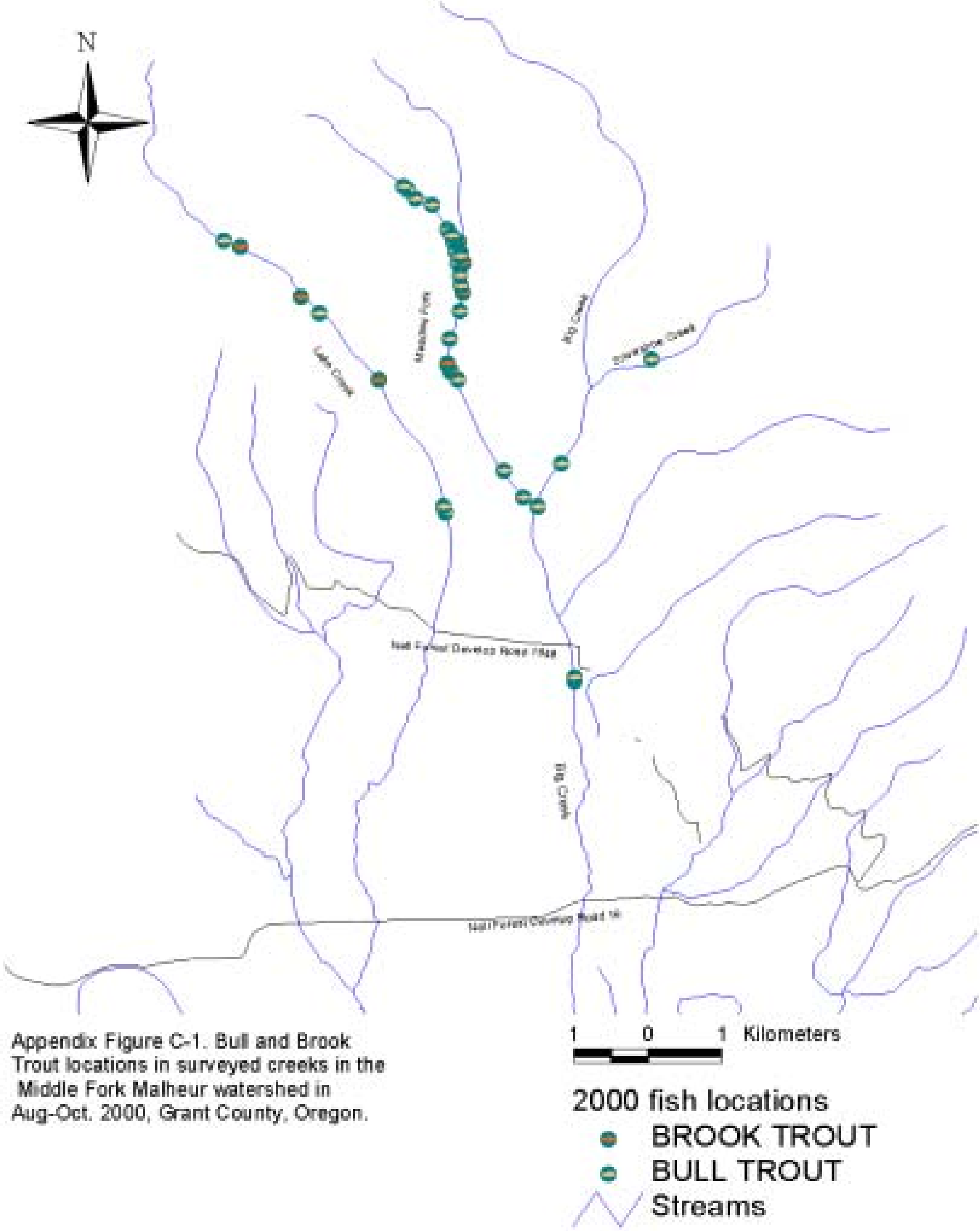

Appendix Figure B-3. Redd and survey locations in Big Creek in Aug-Oct. 2000, Grant County, Oregon.



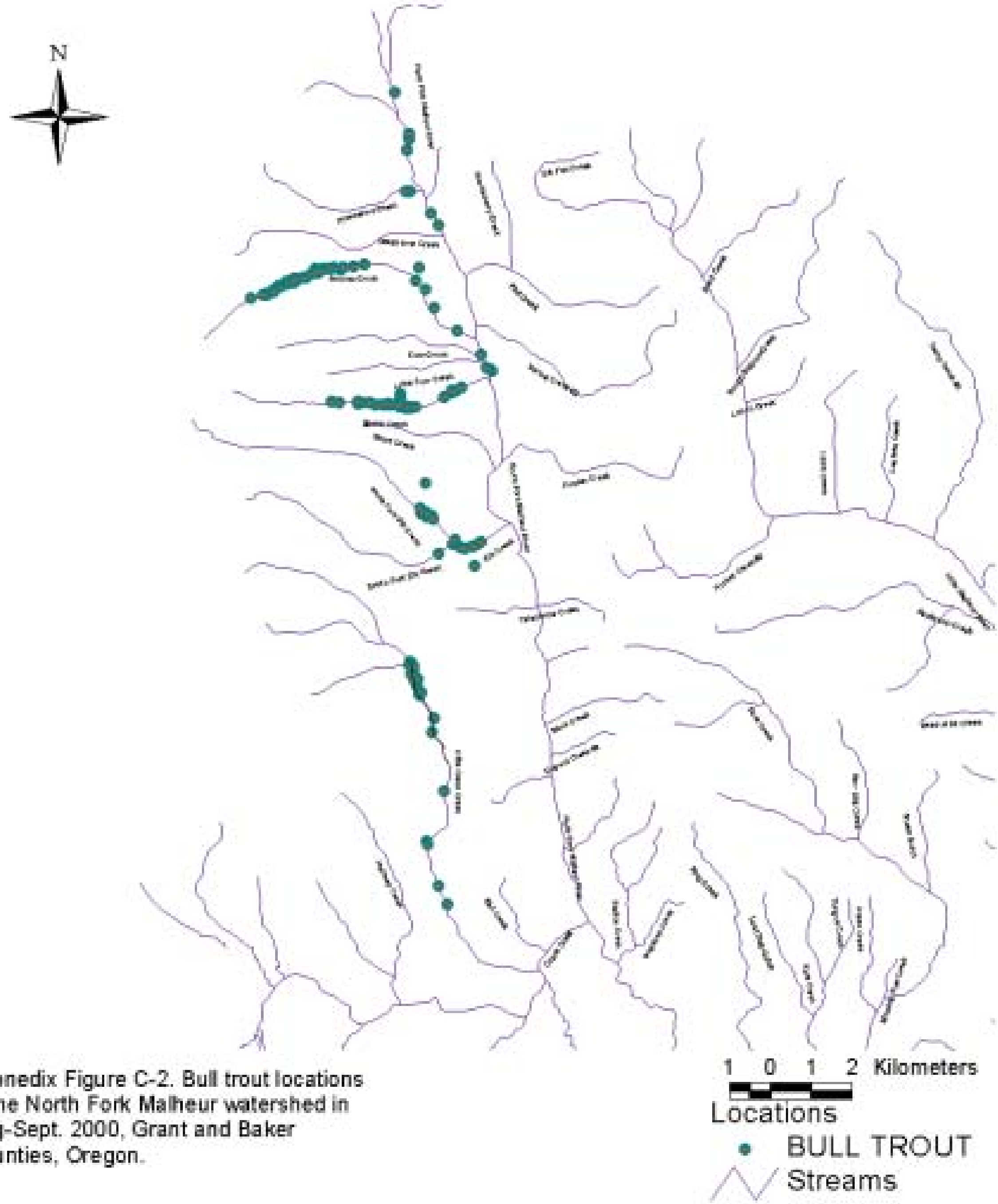

Appendix Figure B-4. Redd and survey locations in Lake Creek in Aug- Oct 2000, Grant County, Oregon.

# APPENDIX C

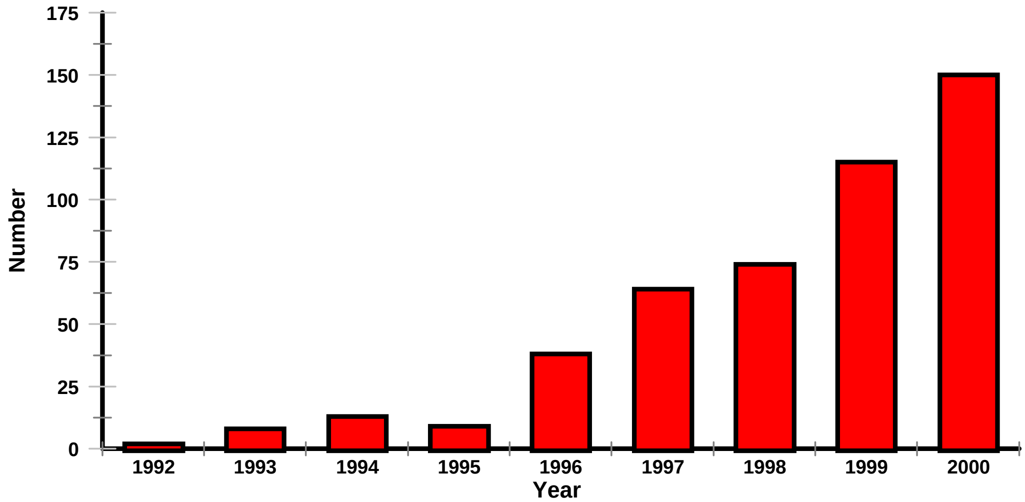
Locations of Bull trout and Brook trout Observed on Spawning Surveys in the Upper Malheur River Malheur and North Fork Malheur Watersheds in Aug-Oct. 2000, Baker and Grant Counties, Oregon.



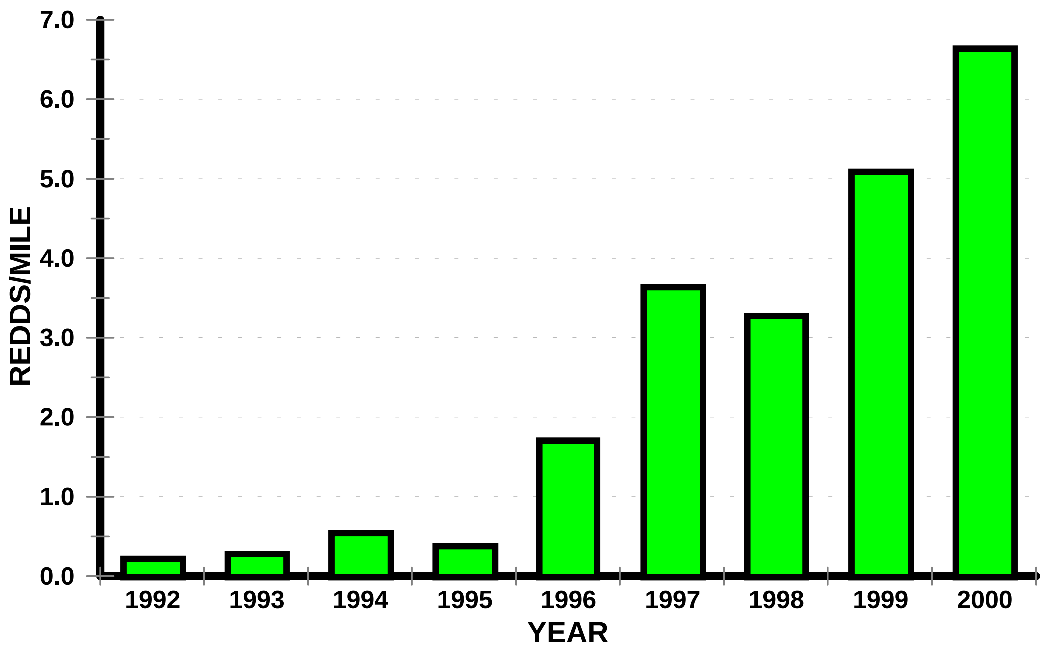

Appendix Figure C-1. Bull and Brook Trout locations in surveyed creeks in the Middle Fork Malheur watershed in Aug-Oct. 2000, Grant County, Oregon.



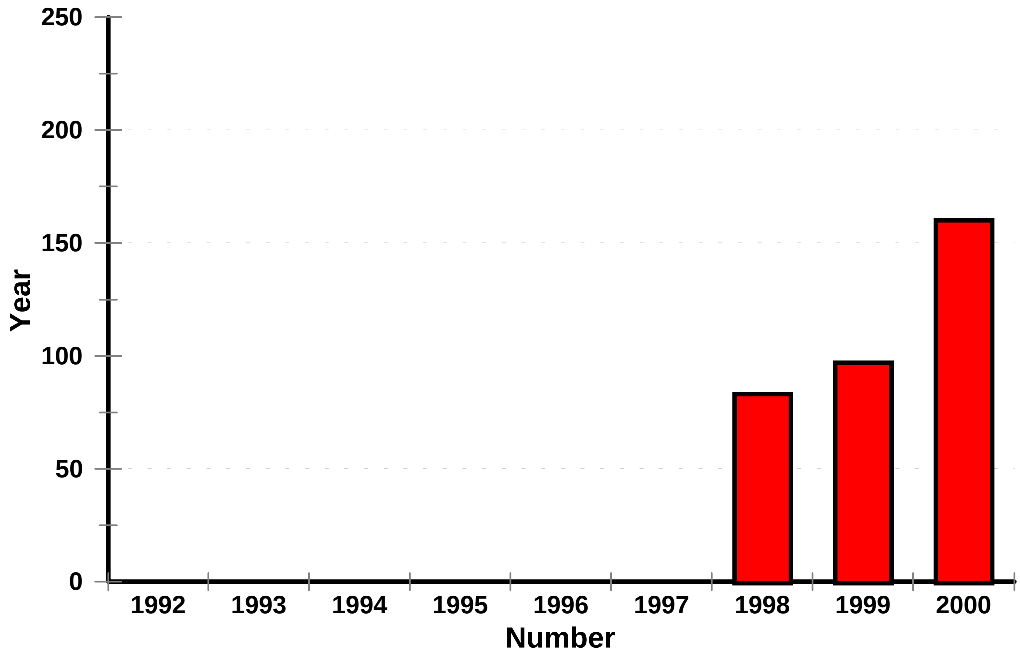

Appnedix Figure C-2. Bull trout locations in the North Fork Malheur watershed in Aug-Sept. 2000, Grant and Baker Counties, Oregon.




Appendix Figure C-3. The number bull trout redds observed in the North Fork Malheur River watershed from 1992-2000.




Appendix Figure C-4. The number bull trout redds per mile of stream observed in the North Fork Malheur River watershed from 1992-2000.




Appendix Figure C-5. The number of brook trout and bull trout redds observed in the upper Malheur River watershed from 1998-2000.

# Entrainment of Bull Trout at Agency Valley Dam

Author: Jason Fenton, Burns Paiute Tribe Fish and Wildlife Department, Burns, Oregon

## Introduction

The United States Bureau of Reclamation (USBR), Oregon Department of Fish and Wildlife, and the Burns Paiute Tribe have determined that bull trout *Salvenlinus confluentus* entrainment occurs over the Agency Valley Dam through its spillway (Schwabe 2000). Bull trout are listed as a threatened species due to past land management activities, which include the construction of dams and fish eradication projects by poisoning (Bowers et al. 1993).

In 1998 and 1999, a migrational study on bull trout was conducted. In both years, radio tagged bull trout were observed in Beulah Reservoir on their way to the headwaters by mid April to late May (Schwabe 2000). The Vale Irrigation District, in accordance to irrigation demands, started to release water from the reservoir in mid-March. During the periods of water release, there was a risk of bull trout entrainment through the Agency Valley Dam. Bull trout were still being observed in the reservoir from mid-March through June. In previous research, (Schwabe 2000) bull trout have been documented leaving the reservoir during these periods of irrigation withdrawals and returning from post spawning/migrational activities prior to cessation of water releases.

Currently, there are no fish passage facilities at Agency Valley Dam for upstream migrating or entrained fish. During the 1998 and 1999 irrigation storage release periods, water was released over the spillway. This resulted in the entrainment of radio tagged bull trout from the reservoir. Changes in the 2000 irrigation season resulted in the release of water through the flow valves rather than over the spillway to try to reduce the number of entrained bull trout. The Burns Paiute Tribe and partners developed the following objectives for this study:

1) Identify bull trout entrainment in response to water management activities.

2) Determine if the release of water from the tubes will reduce the rate of entrainment of radio tagged fish in comparison to traditional water management practices.

## Methods

Creel surveys were conducted for six hours a day, three times a week from mid-March to mid-June in 1999 and 2000. All anglers within ¼ mile below the dam were creeled. The surveys consisted of recording catch per effort (number of fish per hour) for the total hours fished per angler. Bull trout that were angled were collected in a bucket with an aerator and transported above the dam to be released in the reservoir. Fall creel surveys started at the beginning of August and ended in early November, after the tubes closed on October 15th 2000.

## Results

Between mid-March and mid-June 1999, 20 bull trout, at a rate of 0.05 fish per hour, were angled in the tailrace and released above the dam (Table 1). During this same time period in 2000, five bull trout were angled at a rate of .01 fish per hour. In 2000 there was a reduction in the catch rate for bull trout of 80 percent.

Creel data on rainbow trout *Oncorhynchus mykiss* was also collected between mid-March and mid-June 1999 and 2000. In 1999, 150 rainbow trout were angled at a rate of .34 fish per hour. In 2000, only 107 rainbow trout with a catch rate of .21 fish per hour were angled. In 2000 there was a reduction in the catch rate for rainbow trout of 61 percent.

Between August and November of 2000, no bull trout and 4 rainbow trout were angled. There were no fish creels in the fall of 1999. These results were from the days that were creeled. There may have been more bull trout and rainbow trout angled on the days that were not creeled.

Table 1. Catch rate (#/hour) for 1999 and 2000

| | # Fish Caught in Spring | | # Fish Caught in Fall | |
|---|---|---|---|---|
| | Bull Trout | Rainbow | Bull Trout | Rainbow |
| 1999 | 20 | 150 | Na* | Na* |
| 2000 | 5 | 107 | 0 | 4 |
| | Catch Rate (#/hour) for Spring | | Catch Rate (#/hour) for Fall | |
| | Bull Trout | Rainbow | Bull Trout | Rainbow |
| 1999 | 0.05 | 0.34 | Na* | Na* |
| 2000 | 0.01 | 0.21 | 0.00 | 0.02 |

* No creel in fall of 1999.

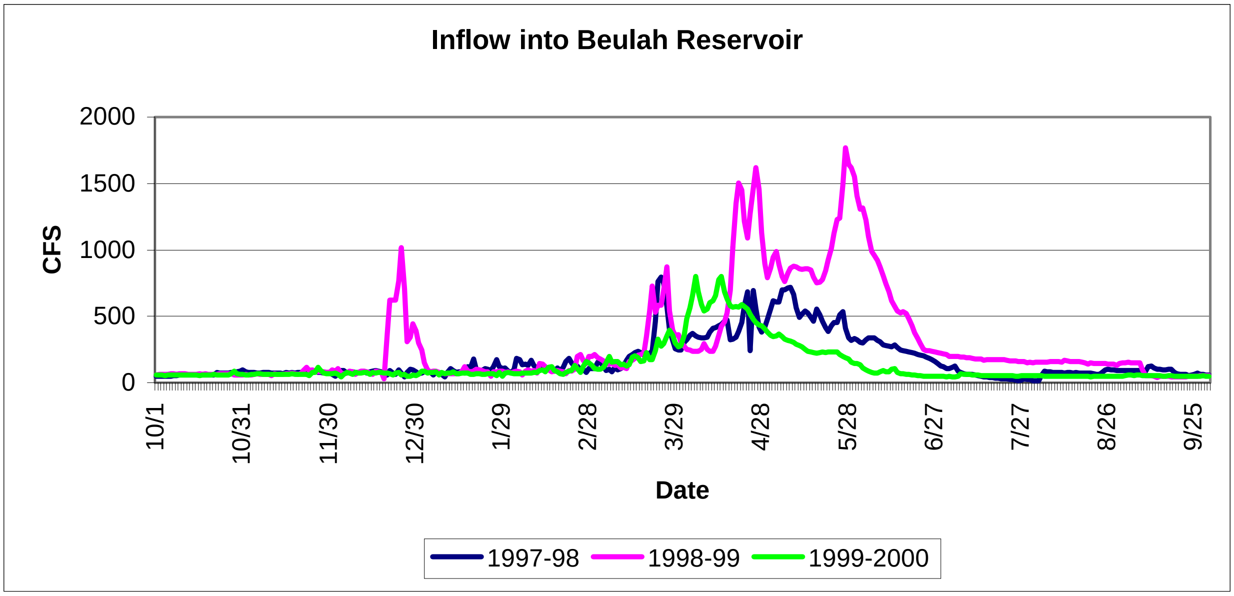
## Discussion

It is presumed that bull trout caught below the spillway in 2000 were entrained.
During the period of 1998-1999, it was documented that four fish were entrained over the spillway (Schwabe 2000). Currently there are no known active water quality parameters enforced or in practice below the reservoir. Therefore, the survivability of entrained salmonids, which require a higher standard of water quality (lower temperatures), is minimal to non-existent during late spring to early fall. Furthermore, it is assumed that bull trout caught below the spillway are coming from the reservoir and not from downstream habitats.

The catch rate for bull trout angled during the creel survey below the spillway when water is released from the tubes is less than when water is released over the spillway (Table 1). The data collected suggests that releasing water from the flow valves rather than the spillway would help reduce but not eliminate bull trout entrainment. Future creel surveys will help to verify entrainment rates.

The flow valves can output a maximum of 650 cubic feet per second (cfs). If outflow exceeds more than 650 cfs, the Vale Irrigation District has to release water over the spillway (Reiber, personal communication 2000). Between 1998 and 2000, the inflow to Beulah reservoir has exceeded 650 cfs (Table 2) during the months of April through June. Depending on reservoir levels, there is a risk that water released over the spillway may occur during years with above-average precipitation and snow pack. The 1999 tracking data indicates that if the spillway is only used from mid-June to early October, entrainment of bull trout may be reduced since the bull trout tend to be upstream during this time (Schwabe 2000). There is no data showing whether juvenile bull trout (<315mm) are entrained. However, there have been observations through creel surveys that indicate the presence of juvenile and sub-adult bull trout in the tailrace of the spillway. It is assumed that these juvenile fish were entrained. Creel surveys for 2001 will be conducted in the spring and fall to continue monitoring fish populations below Agency Valley Dam.

Table 2. North Fork Malheur Inflow from 1997 through 2000. Raw Data Provided by USBR




**References**


Bowers, W.L., P.A. Dupee, M.L. Hanson, and R.R. Perkins. 1993 Bull Trout Populations Summary Malheur River Basin. Oregon Department of Fish and Wildlife, Hines, Oregon. Unpublished report.

Reiber, Rick. Personal communication, Employee of United States Bureau of Reclamation 2000.

Schwabe, L.T. 2000 Malheur River Basin Cooperative Bull Trout/Redband Trout Research Project. Use of Radio Telemetry to Document Movements of Bull Trout in the Malheur Basin in Oregon. Fiscal Year 1999 Annual Report. Unplublished Data. Burns Paiute Tribe Fish and Wildlife Department. Burns, Oregon.

## Use of stream surveys and temperature data to assess habitat conditions on the Malheur River, Oregon.

Author: Lawrence Schwabe, Burns Paiute Tribe Fish and Wildlife Department, Burns, Oregon

Habitat degradation, migration barriers from irrigation projects, and introduced salmonid have been linked to the decline of bull trout *Salvelinus confluentus* populations (Ratliff and Howell 1992, Rieman and McIntyre 1993, Goetz 1994). The patchy distribution of bull trout in relation to other species suggest that these fish have specific habitat requirements and may be prone to habitat disruption and fragmentation (Fraley and Shepard 1989). Rieman et al. (1993) noted five habitat characteristics that appear to be particularly important for bull trout and include: (1) stream channel stability, (2) habitat complexity, (3) substrate composition, (4) temperature, and (5) migratory corridors. Changes in the forest canopy, riparian shading, and in hydrologic patterns have altered stream temperatures (Anderson 1973; Rishel et al. 1982; Barton et al. 1985; Beschta et al. 1987; McGurk 1989). Although there is no direct evidence that alteration of temperature patterns has influenced the persistence or distribution of bull trout, a strong association between temperature and distribution make such a response likely (Rieman and McIntyre 1993).

The Burns Paiute Tribe (BPT), Oregon Department of Fish and Wildlife (ODFW), Bureau of Reclamation (USBR) and the US Forest Service (USFS) set the following objectives for the Upper Malheur River:

1). Identify the temperature profile of the upper Malheur River using stream temperature probes and Forward Looking Infrared (FLIR) Videography.

2). Identify habitat conditions of the upper Malheur River from data collected during habitat surveys. Format consistency with other reports

Isolated reports of bull trout have been documented in the Upper Malheur River (Figure 1). In the spring of 1993, an angler caught and released a bull trout in the Upper Malheur at river kilometer (RK) 286 (Buchanan et al. 1997). The BPT documented radio tagged bull trout at RK 296 in June 2000 (pp. 9-29). The bull trout population in the Upper Malheur River is considered at “high risk” of extinction (Ratliff and Howell 1992).

## Methods

The study area includes the Upper Malheur River from Warm Springs Reservoir to Logan Valley where Lake and Big Creek converge (RK 306)(see page 3). Habitat and temperature surveys were conducted on USFS and Tribal lands (Figure 1). In addition, Forward Looking Infrared (FLIR) Videography surveys were conducted from Warms Springs Reservoir (RK 211) upstream to the headwaters.

### *Stream Surveys*

Stream surveys were conducted on the Upper Malheur River from River Kilometer (RK) 286 to 304 using ODFW Salmon Trout Enhancement Project (STEP) stream inventory protocol (ODFW 1999). This inventory does not include data on undercut banks, which are critical habitats for juvenile bull trout (Dambacher et al. 1997). Therefore, lengths of undercut banks were visual estimated in meters and recorded during these surveys on the Upper Malheur River. Stream survey data was entered into the ODFW d-base program. Data analysis and reports were generated from this program.

The Upper Malheur River habitat survey began at the USFS boundary at RK 286 and continued for 19,094 meters. The Upper Malheur River was broken into four reaches. The reaches were designated based on changes in channel morphology/form and land use. Reach 1: (T18S R34E Sec 9 SE/SE) Surveyed length 10,788 meters. Reach 1 begins at the USFS boundary and ends at the Malheur Ford (RK 296). Reach 2: (T17S R34E Sec 18 SE/SW) Surveyed length 1642 meters. Reach 2 begins at the Malheur Ford and ends at the confluence with Summit Creek (RK 298). Reach 3: (T17S R33 ½ E Sec 13 SE/NE) Surveyed length 5,898 meters. Reach 3 begins at the confluence of Summit Creek (RK 298) and ends at RK 303.5 (about 1 km downstream of the Burnt River Bridge Crossing). Reach 4: (T17S R33 ½ E Sec 2 NE/NW) Surveyed length 766 meters. Reach 4 begins at RK 303.5 and end at the USFS boundary (RK 304).

### *Forward Looking Infrared (FLIR) Videography*

Thermal infrared images collected on the Upper Malheur River survey are used to develop broad scale temperature patterns in the basin. The images were collected using a helicopter mounted Thermal Infrared Radiometer (TIR also know as FLIR). The radiometer was co-located with a day TV video camera in a gyro-stabilized gimbal mount and images were collected by flying longitudinally over the center of the stream channel. The TIR images were tagged with position information from a global positioning system (GPS) and recorded directly to an on-board computer. The imagery from the Day TV camera was also tagged with GPS positions and recorded to a videocassette recorder on the helicopter. The survey was conducted between 2:27 pm and 3:00 pm on 7-8 August 1998.

The radiometer measures the thermal infrared energy emitted from the water's surface as well as other objects in the scene. The measured energy is converted to temperature by knowing the conditions under which the images were collected and the emissivity of water. As a result, each pixel in the image represents the radiant temperature at that location.

*Stream Temperature Probes*

Six stream temperature thermographs were deployed in the Malheur River in 2000. Thermographs were deployed under the guidelines outlined in the Oregon Department of Environmental Quality (1998). Temperature probes were program to take at least one temperature reading every 90 minutes. Thermographs are calibrated before and after field season use to be consistent with the Oregon Department of Environmental Quality's protocol. Onset Hobo XT and Stowaway thermographs were used to monitor stream temperatures. The Burns Paiute Tribe deployed 4 stream temperature thermographs in the Upper Malheur River and the Forest Service deployed 2.

Site #1. - River kilometer 287.5 – BPT temp site
Site #2. - River kilometer 295.5 – BPT temp site
Site #3. - River kilometer 296 – USFS temp site (the Malheur Ford)
Site #4. - River kilometer 300.5 – USFS temp site
Site #5. - River kilometer 304 – BPT temp site (Weir Trap)
Site #6. - River kilometer 306 – BPT temp site

The rate of temperature increases was figured between temperature sites. The rate of temperature change is expressed as: change in temperature ($^oC$) / distance between temperature sites (kilometers). Change in temperature ($^oC$) is figured by: the difference between the maximum daily high stream temperature ($X^1 – X^2$), $X^1$ and $X^2$ representing stream temperature sites. Statistical analysis was done in Excel 97. Temperature change per kilometer was figured between sites. Student t-tests were conducted to determine the if their was significant difference in the rate of temperature change between sites.

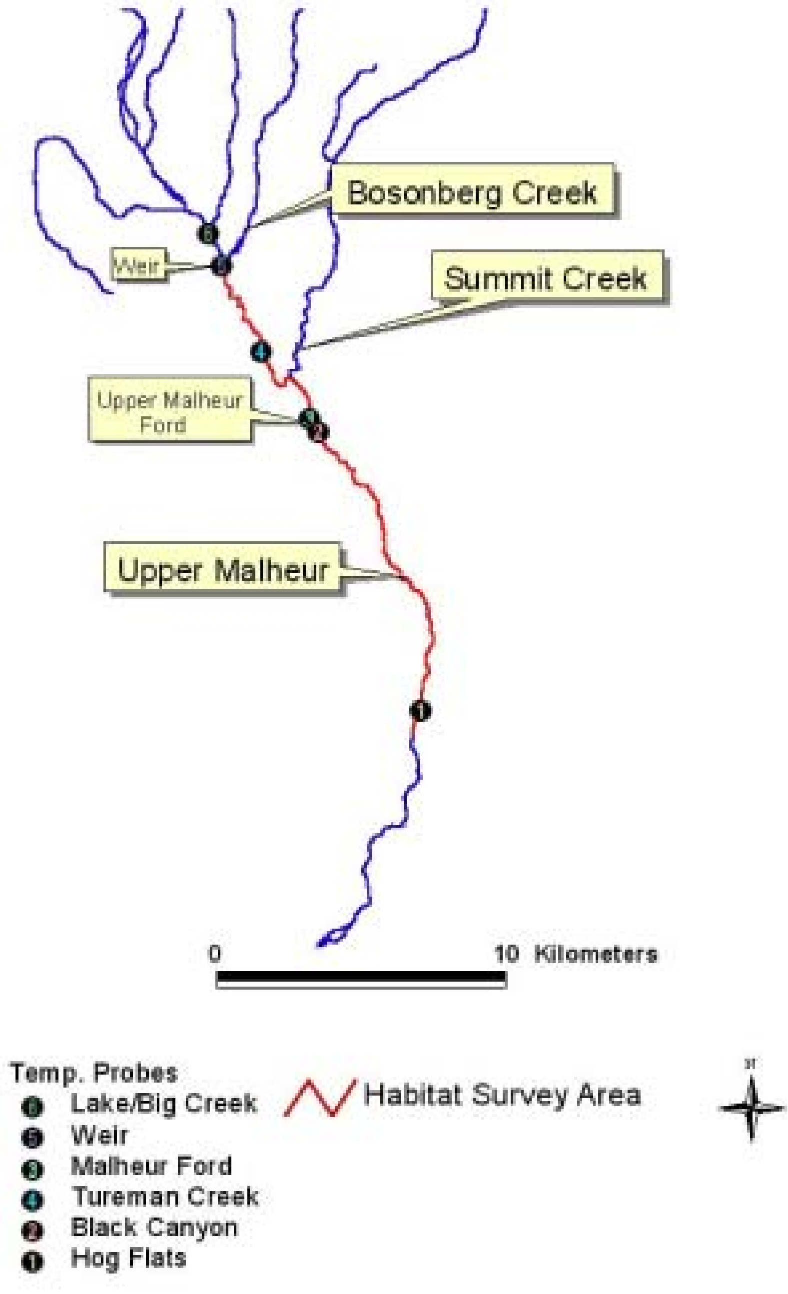



**Figure 1.** Location of stream temperature probes and habitat survey study area in 2000 on the Upper Malheur River.

## Results

*Stream Habitat Surveys*

Total pieces of Large Woody Debris (LWD) ranged from 0 pieces per 100 meters in Reach 4 to 11 pieces of LWD/100 meters in Reach 3 (Figure 2). Percent active erosion per reach was highest in Reach 4 at 30% while Reach 1 had no observed active erosion (Figure 3). Reach 1 and 3 had higher boulder counts and a higher percentage of fast water habitats (riffles and rapids)(Figure 4 and 5).

Reach 1: Access to this reach is primarily by foot trail with all road access limited to the ridge tops adjacent to the river. Channel gradient for this reach is 1.7%. Stream habitat is comprised of riffle (85%) and rapid habitat (10%). Stream substrate is dominated by cobble (46%), boulder (27%), and gravel (19%). Total LWD pieces per 100 meters of stream is 3.1. Percent shade in this reach is higher than the other reaches surveyed (61%)(Figure 6) with no observed active erosion. The trees most frequently found in the riparian zone (zone 1) are hardwood species.

Reach 2: Access to this reach is limited to the road crossing at the Malheur Ford. Channel gradient for this reach is 0.9%. Stream habitat is comprised of riffle (48%) and glide habitat (42%). Stream substrate is dominated by cobble (45%), gravel (34%), and boulder (11%). Total LWD pieces per 100 meters of stream is 5.1. Percent shade for this reach is 52% with 6% active erosion. The trees most frequently found in the riparian zone (zone 1) are conifer species.

Reach 3: Best access to this reach is using both closed and open forest service roads on the west bank and hiking down the hillslope. Channel gradient for this reach is 1.2%. Stream habitat is comprised of riffle (69%) and glide habitat (23%). Stream substrate is dominated by cobble (37%), gravel (31%), and boulder (18%). Highest levels of LWD were observed within this reach. Total LWD pieces per 100 meters of stream are 11.6. Percent shade for this reach is 48% with 10 percent active erosion. The trees most frequently found in the riparian zone (zone 1) are conifer species.

Reach 4: Best access to this reach is using forest service roads that cross the Malheur River at Burnt Bridge Crossing (RK 304). Channel gradient for this reach is 0.9%. Stream habitat is comprised of glide (45%), pool (28%), and riffle habitat (27%). Stream substrate is dominated by gravel (43%), cobble (33%), and boulder (16%). Total LWD pieces per 100 meters of stream is 0. Percent shade for this reach is 0% with 30% active erosion. The trees most frequently found in the riparian zone (zone 1) are conifer species. Stream survey data analysis generated from ODFW d-base program and riparian survey data can be viewed in Appendix A.

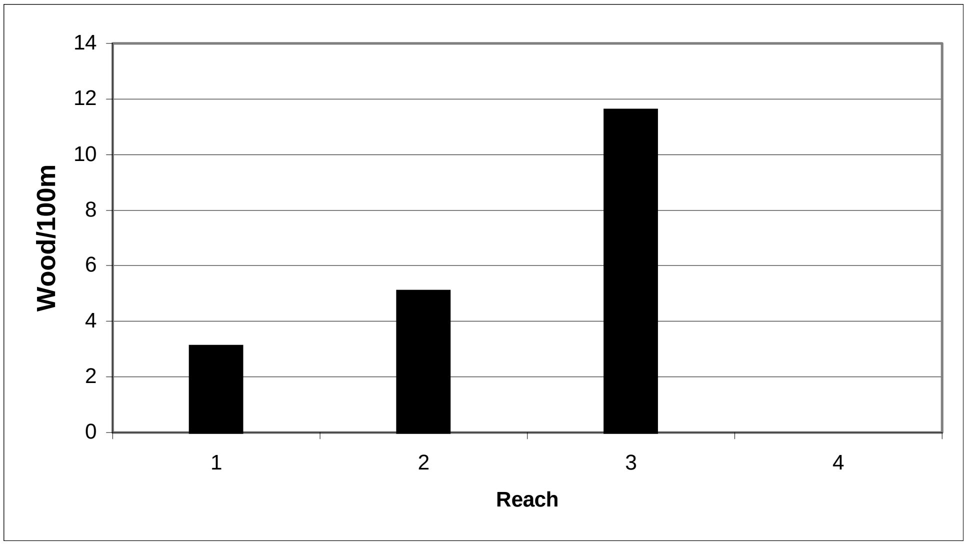



Figure 2. Stream survey conducted on the Upper Malheur River included counts of Large Woody Debris (LWD). Graph illustrates by reach the density of LWD per 100 meters of stream.

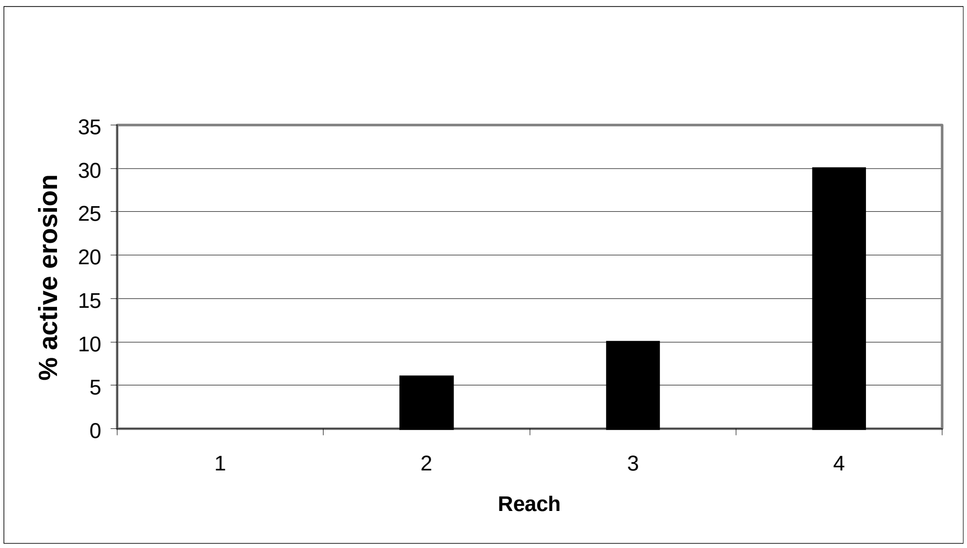



Figure 3. Stream survey conducted on the Upper Malheur River in 2000 included estimated length of active eroding banks. Graph illustrates by reach the percent of active erosion. Percent of active eroding bank per reach is figured by length of active eroding bank / Length of reach X 2.

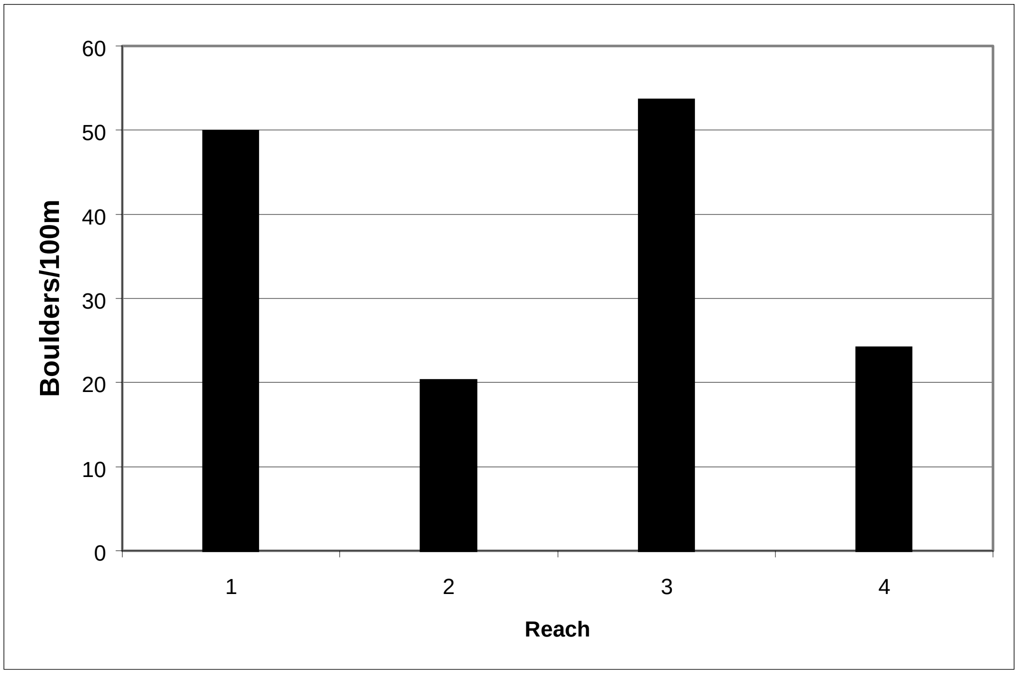



Figure 4. Stream survey conducted on the Upper Malheur River in 2000 included boulder counts. Graph illustrates by reach the number of boulders per 100 meters of stream channel.

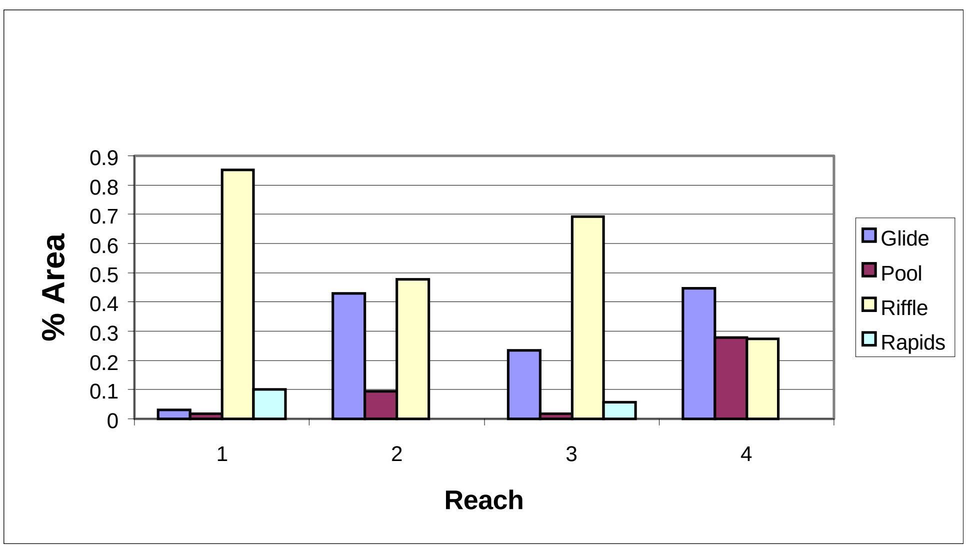



Figure 5. The stream survey in 2000 estimated area of different habitat types on the Upper Malheur River. The above graph illustrates percent habitat area per reach of being one on the following dominant habitat types: pool, glide, riffle or rapid. Riffle with pocket units were lumped into riffle habitat. Dam pools, lateral scour pools, backwater pools and straight scour pool units were lumped into pool habitat. Glides and rapids represent themselves.

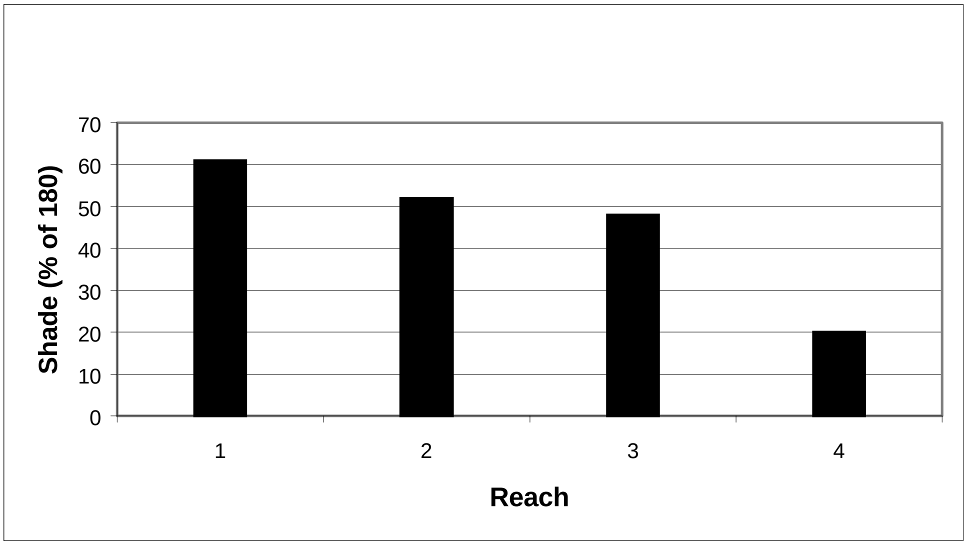



Figure 6. Stream survey conducted on the Upper Malheur River in 2000 included estimating shade every habitat unit. Graph illustrates the average percent of shade recorded by reach.

*Forward Looking Infrared (FLIR) Videography*

Data collected from the FLIR flights were entered into the Geographic Information System (GIS). A GIS map printout of the data illustrates stream temperature characteristics and variations in the Upper Malheur River (Figure 7). The data collected during the 1998 survey suggested a cold-water source located below the Malheur Ford at RK 294 and 1.5 km below Bosenburg Creek (UTM 0370966E 4886749N).

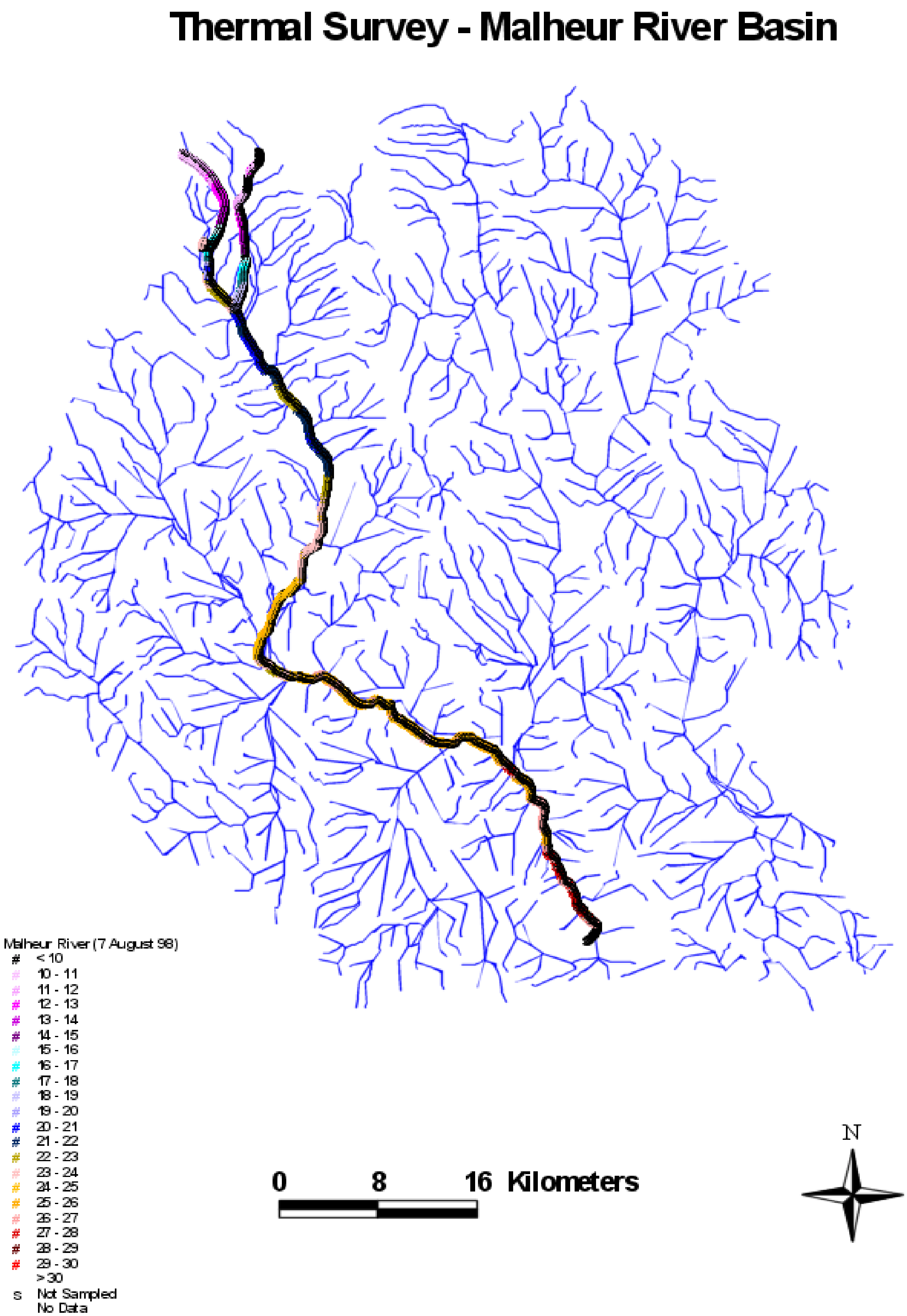



Figure 7. FLIR flight data for the Upper Middle Fork from Warm Springs Reservoir to the headwaters

*Stream Temperature Data*

Of the six stream temperature hydrographs deployed in the Upper Malheur River, five temperature gauges provided satisfactory results and met the requirements in the Oregon DEQ protocol. All stream temperature probes were deployed by 22 June 2000 and removed by 2 November 2000 (Table 1). The data collected at site 5 will not be incorporated into this report. Site 5, located below Bosonberg Creek, was the only temperature hydrograph that did not function properly due to manufacture defect. Stream temperature data from the five temperature probes on the Upper Malheur River exceeded Oregon State water quality standards for bull trout during the summer of 2000 (pp. 86-108). Figure 8 is a record of daily maximum stream temperatures for the Upper Malheur River.

Site 6 (RK 306), the uppermost site, recorded the coolest temperatures. Four of the five temperature probes recorded maximum high temperatures on 29 July 2000. Plotting temperature vs. River Kilometer for 29 July 2000, stream temperatures generally increase downstream (Figure 9). The exception is from site 3 to site 2 where stream temperature decreased 1.1$^{o}$C on 29 July 2000.

Table 1. Dates for deployment and retrieval of stream temperature probes on the Malheur River.

| Stream Temperature Site | Date Deployed | Date Retrieved |
|---|---|---|
| Site #1 | 5/31/00 | 11/2/00 |
| Site #2 | 6/2/00 | 10/17/00 |
| Site #3 | 6/7/00 | 10/21/00 |
| Site #4 | 6/8/00 | 10/17/00 |
| Site #5 | 6/2/00 | 10/22/00 |
| Site #6 | 6/22/00 | 9/18/00 |

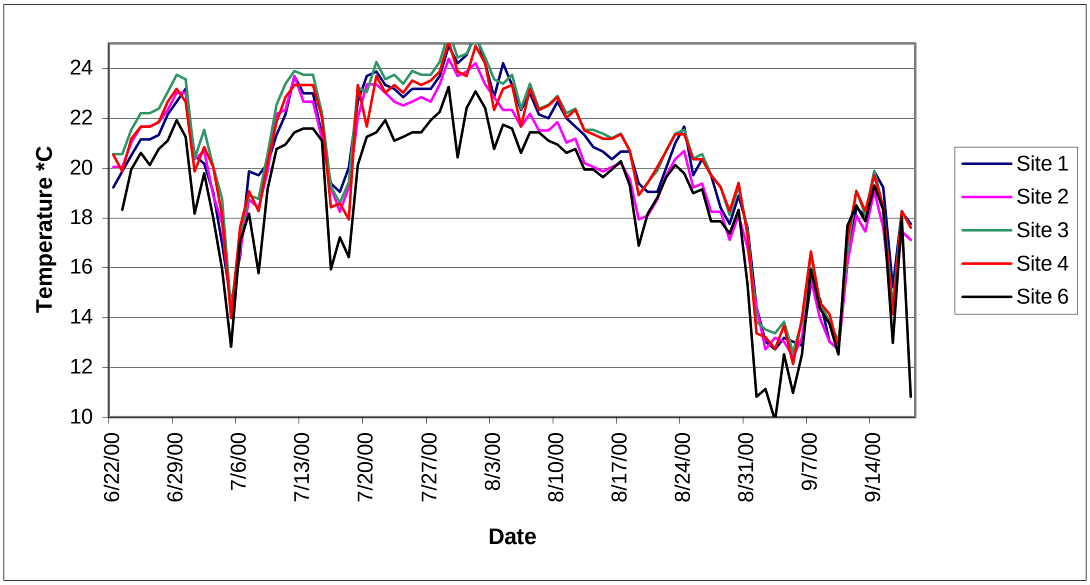



Figure 8. Daily maximum temperatures on the five temperature data loggers deployed in the upper Malheur River.

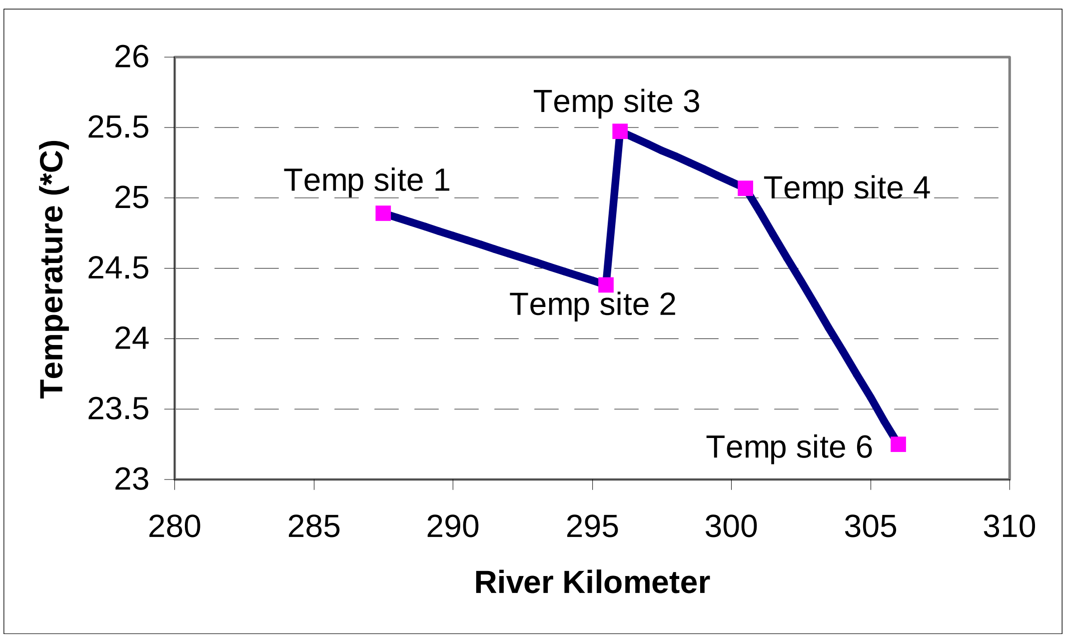



Figure 9. Maximum temperature ($^{O}$C) on 29 July 2000. Temperature sites 2-6 recorded maximum temperatures on this date. Temperature site 1 did not record peak temperature on this date. Peak temperature for Site 1 occurred on 1 Aug 2000. The second warmest temperature for site 1 occurred on 29 Jul 2000.

## Discussion

An increase risk of extinction may occur with the cumulative loss or otherwise persistent change of critical habitat within the species environment (Gilpin and Soule 1986). Due to the high risk of extinction, bull trout in the Upper Malheur River are threatened. Therefore, it is critical to understand the effects land managers have on fish populations. Land managers may have to apply conservative land management practices in order to effectively restore and benefit bull trout and other resident fish in the Upper Malheur River.

Wild and Scenic management restrictions coupled with poor access may explain the light impacts observed on the lower three reaches of the Upper Malheur River (RK 286 to 303.5). Channel characteristics for these three reaches resemble a Rosgen B channel type (Rosgen 1996). Though hardwood counts in the riparian are low, the stream survey conducted on reaches 1 through 3 detect no direct management impacts to the stream channel and encourage land managers to continue maintain current management activities.

Reach 4 (RK 303.5 to 304) had high levels of active erosion, low shade, and low riparian hardwood counts. Width to depth ratio for this reach is relatively high. Surveys noted high cattle impacts to the channel and riparian vegetation (ie. overgrazed willow, post holing, trampled banks, presence of cattle). The data and information collected from reach 4 suggest that cattle grazing may be having a negative effect on the channel and riparian conditions. Bull trout have been documented in this area from June through October (pp. 9-29). Management recommendations to land managers include riparian fencing, riparian planting, off site stock water development or change in allotment management.

Water temperatures in the Upper Malheur River exceed DEQ maximums (pp. 86-108). In the months of July and August 2000, the rate of stream temperature change per kilometer of stream was determined to identify areas of accelerated warming and cooling (Table 2). Two sample t-tests were used to determine significant changes in stream temperature (Appendix B). Significant warming of stream temperatures occurred from RK 300.5 to RK 306 (p-value = 0.000). From RK 287.5 to 300.5, stream temperatures increased at a fairly constant rate with no significant difference (p-value= 0.936) except for a significant change in temperature on a 0.5 km section of stream (p-value= 0.000). From the Malheur Ford (RK 296) downstream to temp site #2 (295.5), the average daily max stream temperatures decreased 0.9$^{o}$C in July and August.

Table 2. List of active temperature sites and the change in temperature per site. The change in temperature can be expressed in the rate of change per kilometer.

| Stream Temp Site # | Distance between Temperature Probes (km) | Average Change Temp ($^{o}C$) | Average Change in Temp per Kilometer |
|---|---|---|---|
| Site 1 and 2 | **8.0** | **0.546935** | **0.068367** |
| Site 2 and 3 | **0.5** | **0.901520** | **1.80305** |
| Site 3 and 4 | **4.5** | **0.302975** | **0.067327** |
| Site 4 and 6 | **5.5** | **1.56** | **0.284633** |

In addition, data generated by the FLIR survey conducted in 1998 has determined an area of cold-water refugia located 2 km below the Malheur Ford (RK 296) (Figure 10). Data from FLIR suggest a cool water source located at RK 294 while stream temperature probes record a cold-water source entering the Upper Malheur River at RK 295.5. Reasons for inconsistencies in the data may be due to the level of temperature measurement. FLIR measures temperature in full degrees ($^{O}C$) while stream temperature probes measure to the nearest tenth of a degree ($^{O}C$). Continued monitoring of the stream temperature sites will help determine if discrepancies in the data is a product from the temperature data loggers.

A significant increase in temperature occurred from RK 306 to 300.5. This would include all of reach 4 and half of the upper 3 km of reach 3. This area was noted to have management resource impacts to the channel and riparian areas. Also, a significant decrease in temperature occurred below the Malheur River Ford (RK 296) suggesting a cool-source of water affecting the mainstem is present. Research needs to be conducted to determine: (1) the source and temperature of the cold water, (2) bull trout and other salmonid use cold water refugia areas during the peak summer stream temperatures. By identifying cold-water sources and salmonid use of these areas in the Upper Malheur River Basin, land managers can protect these areas from land management activities that may have significant impacts to these micro-habitats. Furthermore, improving habitat conditions in the tributaries that flow into the Upper Malheur River can enhance water quality conditions in the Upper Malheur River.

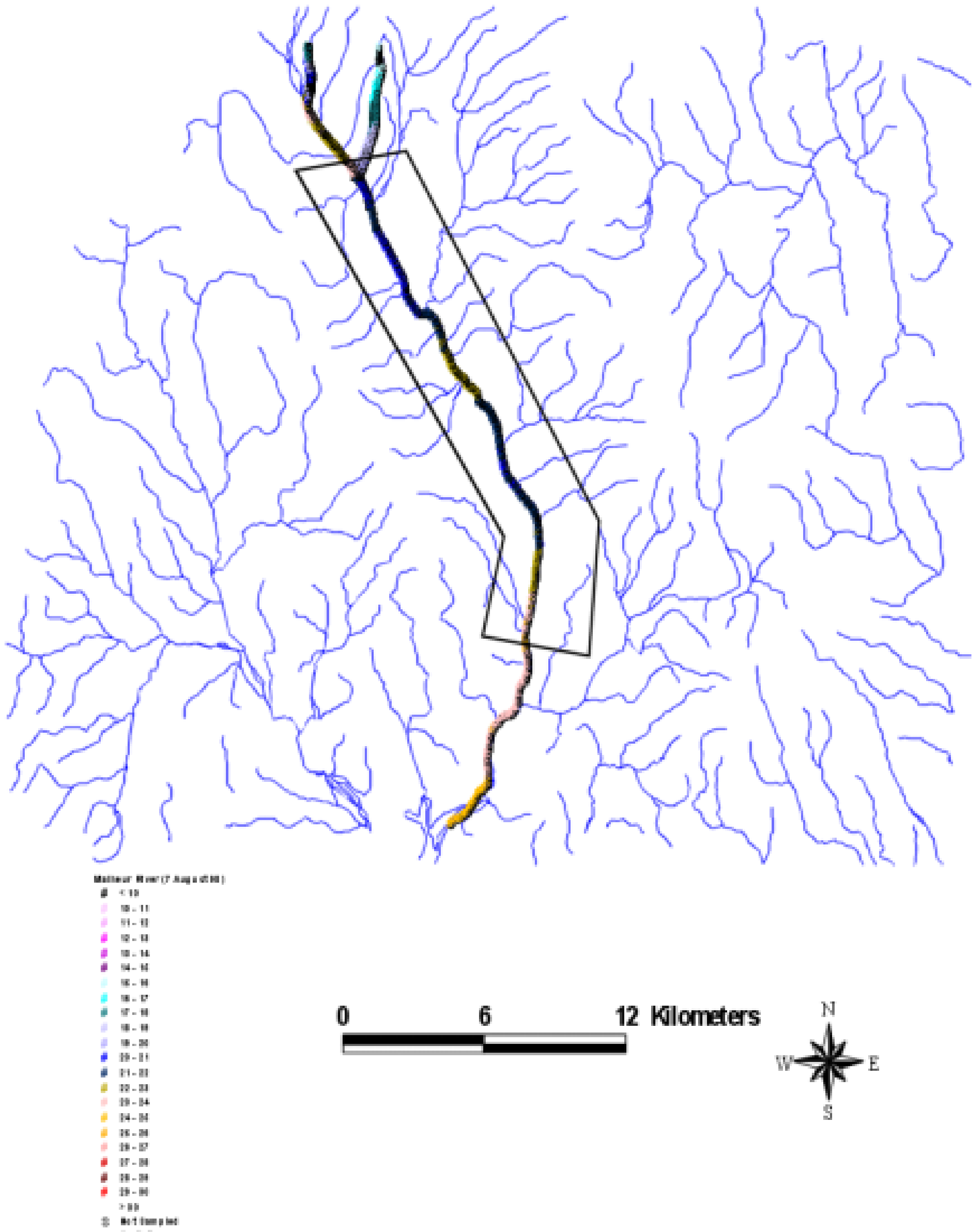



**Figure 10.** FLIR flight data from US forest Service Boundary to the confluence of Lake and Big Creek.

**Acknowledgements**

A special thanks is extended to: Jim Supior (USFS) for coordinating stream temperature probe sites and data; Kim Jones (ODFW) and Jeff Dambacher (ODFW) for assisting the department with habitat survey quality control; Nick Miller (ODFW), Mark Tiley (BPT), and Newton Skunkcap (BPT) for hours of field work.

## References

Anderson, H.W. 1973. The effects of clear cutting on stream temperature, a literature review. Rep. No. 29. Olympia, WA: Washington Department of Natural Resources.

Barton, D.R., W.D.Taylor and R.M. Biette. 1985. Dimensions of riparian buffer strips required to maintain trout habitat in southern Ontario streams. North American Journal of Fisheries Management. 5: 364 – 378.

Beschta, R.L., R.E. Bilby, G.W. Brown, L.B. Holtby and T.D. Hofstra. 1987. Stream temperature and aquatic habitat: fisheries and forestry interactions. In: Salo, E.O. Cundy, T.W. eds. Streamside management: forestry and fishery interaction. Seattle, WA: University of Washington: 191-232.

Buchanan, D.V., M.L. Hanson, and R.M. Hooton. 1997. Status of Oregon's Bull Trout. Oregon Department of Fish and Wildlife, Portland.

Fraley, J.J. and B.B. Shepard. 1989. Life history, ecology and population status of migratoy bull trout (Salvelinus confuentus) in the Flathead Lake River System, Montana. Northwest Science. 63(4); 133-143

Gilpin, M.E., M.E. Soule. 1986. Minimum viable populations: processes of species extinction: 13-34. In; Soule, M.E. ed. Conservation biology: the science of scarcity and diversity. Sunderland MA: Sinaur Associates. 584 p.

Goetz, F. A. 1994. Distribution and juvenile ecology of bull trout (*Salvelinus confluentus*) in the Cascade mountains. M.S. Thesis. Oregon State University, Corvallis, Oregon.

McGurk , G.J. 1989. Predicting stream temperature after riparian vegetation removal. Gen. Tech. Rep. PSW-110. Berkeley, CA: US Department of Agriculture, Forest Service.

Oregon Department of Fish and Wildlife. 1999. Aquatic Habitat Inventory Intermediate Level Stream Survey. Portland, OR

Oregon Department of Environmental Quality. 1998. Water Quality Monitoring Handbook. Chapter 6 Stream Temperature Protocol. pp 12 – 29.

Ratliff, D.E. and P.J. Howell. 1992. The status of bull trout population in Oregon. In: Howell P.J.; Buchanan, D.V. eds. Proceedings of the Gearhart Mountain bull trout worshop. Corvallis, R: Oregon Chapter of the American Fisheries Society; 37-44.

Schwabe, L.T. 2001. Evaluate the Life History of Native Salmonids in the Malheur Basin. Use of radio telemetry to document bull trout movements in the Malheur River basin, Oregon. Fiscal Year 2000 Annual Report. Unpublished Data. Burns Paiute Tribe Fish and Wildlife Department. Burns, Oregon.

Rieman, B.E. and J.D. McIntyre. 1993. Habitat and Demographic Requirements of Bull Trout. USDA Forest Service, intermountain Research Station.

Rishel, G.B., J.A. Corbett and E.S.Corbett. 1982. Seasonal stream temperature changes following forest harvesting. Journal of Environmental Quality. 11(1): 112-116.

Rosgen, D. 1996. Applied river morphology. Pub. Highland Hydrology. Pagosa Springs, CO.

## Appendix A.

Data analysis for habitat survey conducted on the Upper Malheur River.

```
OREGON DEPT. FISH AND WILDLIFE                         MF MALHEUR
HABITAT INVENTORY   Report Date: 03/12/01              Survey Date: 07/06/00
ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ
                                HABITAT UNIT SUMMARY
REACH   1                                                                               REACH 1
```

HABITAT DETAIL

| Habitat Type | Number Units | Total Length (m) | Avg Width (m) | Avg Depth (m) | Total Area (m2) | Large Boulders (#>0.5m) | Substrate Percent Wetted Area S/O | Snd | Grvl | Cbbl | Bldr | Bdrk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GLIDE | 7 | 346 | 16.4 | 0.00 | 5,832 | 153 | 1 | 8 | 27 | 44 | 21 | 0 |
| POOL-ALCOVE | 1 | 10 | 2.0 | 0.00 | 20 | 0 | 36 | 18 | 27 | 18 | 0 | 0 |
| POOL-BACKWATER | 2 | 13 | 6.0 | 1.00 | 81 | 8 | 28 | 30 | 10 | 19 | 15 | 0 |
| POOL-LATERAL SCOUR | 7 | 106 | 11.4 | 1.00 | 1,254 | 73 | 2 | 8 | 22 | 40 | 29 | 0 |
| POOL-PLUNGE | 1 | 5 | 26.0 | 1.00 | 130 | 5 | 2 | 5 | 22 | 38 | 33 | 0 |
| POOL-STRAIGHT SCOUR | 8 | 137 | 10.3 | 1.00 | 1,635 | 56 | 4 | 8 | 24 | 34 | 31 | 0 |
| RAPID/BOULDERS | 14 | 1,321 | 14.3 | 0.00 | 19,064 | 1420 | 0 | 4 | 12 | 40 | 44 | 0 |
| RIFFLE | 43 | 5,284 | 17.2 | 0.00 | 100,845 | 2076 | 1 | 4 | 19 | 52 | 24 | 0 |
| RIFFLE W/ POCKETS | 30 | 3,510 | 16.3 | 0.00 | 59,184 | 1580 | 1 | 4 | 20 | 48 | 27 | 0 |
| STEP/BOULDERS | 1 | 3 | 0.0 | 0.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| STEP/COBBLE | 3 | 53 | 13.0 | 1.00 | 683 | 12 | 0 | 7 | 16 | 62 | 15 | 0 |
| | ÄÄÄ | ÄÄÄÄÄÄ | ÄÄÄÄ | ÄÄÄÄ | ÄÄÄÄÄÄÄ | ÄÄÄÄÄ | ÄÄÄ | ÄÄÄ | ÄÄÄ | ÄÄÄ | ÄÄÄ | ÄÄÄ |
| Total: | 117 | 10,788 | 15.2 | 0.18 | 188,728 | 5383 | Avg: 2 | 5 | 19 | 46 | 27 | 0 |

HABITAT SUMMARY

| Habitat Group | No. Units | Total Length (m) | Avg Width (m) | Avg Depth (m) | Wetted Area (m2) | Percent | Large Boulders Number | #/100m2 |
|---|---|---|---|---|---|---|---|---|
| Dammed & BW Pools | 3 | 23 | 4.7 | 0.67 | 101 | 0.05 | 8 | 7.92 |
| Scour Pools | 16 | 248 | 11.8 | 1.00 | 3019 | 1.60 | 134 | 4.44 |
| Glides | 7 | 346 | 16.4 | 0.00 | 5832 | 3.09 | 153 | 2.62 |
| Riffles | 73 | 8,794 | 16.8 | 0.00 | 160029 | 84.79 | 3656 | 2.28 |
| Rapids | 14 | 1,321 | 14.3 | 0.00 | 19064 | 10.10 | 1420 | 7.45 |
| Cascades | 0 | 0 | . | . | 0 | 0.00 | 0 | 0.00 |
| Step/Falls | 4 | 56 | 9.8 | 0.75 | 683 | 0.36 | 12 | 1.76 |
| Dry | 0 | 0 | . | . | 0 | 0.00 | 0 | 0.00 |

POOL SUMMARY

| | Total | #/km |
|---|---|---|
| All Pools | 19 | 1.8 |
| Pools >1m deep: | 17 | 1.6 |
| Complex pools (wood pieces>3): | 5 | 0.5 |
| Pool frequency (channel widths/pool): | 24.7 | |

LARGE WOOD DEBRIS

| | Pieces | Pieces/100m |
|---|---|---|
| Small (>15cm dbh, 3m length) | 157 | 1.5 |
| Medium (>30cm dbh, 6m length) | 139 | 1.3 |
| Large (>60cm dbh, 10m length) | 39 | 0.4 |
| Total - all LWD classes | 335 | 3.1 |

HABITAT UNIT SUMMARY

REACH 2 REACH 2

HABITAT DETAIL

| Habitat Type | Number Units | Total Length (m) | Avg Width (m) | Avg Depth (m) | Total Area (m2) | Large Boulders (#>0.5m) | Substrate Percent Wetted Area S/O | Snd | Grvl | Cbbl | Bldr | Bdrk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 89 | 12.0 | 0.00 | 1,068 | 30 | 0 | 10 | 40 | 40 | 10 | 0 |
| GLIDE | 8 | 661 | 16.6 | 0.00 | 11,039 | 129 | 3 | 9 | 35 | 43 | 10 | 0 |
| POOL-LATERAL SCOUR | 6 | 153 | 15.7 | 1.00 | 2,436 | 62 | 6 | 10 | 31 | 42 | 12 | 0 |
| RIFFLE | 10 | 739 | 16.9 | 0.00 | 12,294 | 112 | 0 | 6 | 34 | 48 | 12 | 0 |
| Total: | 25 | 1,642 | 16.3 | 0.24 | 26,837 | 333 | Avg: 3 | 8 | 34 | 45 | 11 | 0 |

HABITAT SUMMARY

| Habitat Group | No. Units | Total Length (m) | Avg Width (m) | Avg Depth (m) | Wetted Area (m2) | Wetted Area Percent | Large Boulders Number | Large Boulders #/100m2 |
|---|---|---|---|---|---|---|---|---|
| Dammed & BW Pools | 0 | 0 | . | . | 0 | 0.00 | 0 | 0.00 |
| Scour Pools | 6 | 153 | 15.7 | 1.00 | 2436 | 9.08 | 62 | 2.55 |
| Glides | 8 | 661 | 16.6 | 0.00 | 11039 | 41.13 | 129 | 1.17 |
| Riffles | 10 | 739 | 16.9 | 0.00 | 12294 | 45.81 | 112 | 0.91 |
| Rapids | 0 | 0 | . | . | 0 | 0.00 | 0 | 0.00 |
| Cascades | 0 | 0 | . | . | 0 | 0.00 | 0 | 0.00 |
| Step/Falls | 0 | 0 | . | . | 0 | 0.00 | 0 | 0.00 |
| Dry | 0 | 0 | . | . | 0 | 0.00 | 0 | 0.00 |

POOL SUMMARY

| | Total | #/km |
|---|---|---|
| All Pools | 6 | 3.7 |
| Pools >1m deep: | 6 | 3.7 |
| Complex pools (wood pieces>3): | 5 | 3.0 |
| Pool frequency (channel widths/pool): | 14.4 | |

LARGE WOOD DEBRIS

| | Pieces | Pieces/100m |
|---|---|---|
| Small (>15cm dbh, 3m length) | 40 | 2.4 |
| Medium (>30cm dbh, 6m length) | 30 | 1.8 |
| Large (>60cm dbh, 10m length) | 14 | 0.9 |
| Total - all LWD classes | 84 | 5.1 |

HABITAT UNIT SUMMARY

REACH 3 REACH 3

HABITAT DETAIL

| Habitat Type | Number Units | Total Length (m) | Avg Width (m) | Avg Depth (m) | Total Area (m2) | Large Boulders (#>0.5m) | Substrate Percent Wetted Area S/O | Snd | Grvl | Cbbl | Bldr | Bdrk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GLIDE | 27 | 1,501 | 13.0 | 0.04 | 22,006 | 356 | 6 | 8 | 36 | 36 | 15 | 1 |
| POOL-BACKWATER | 5 | 66 | 4.0 | 0.20 | 287 | 3 | 28 | 21 | 41 | 8 | 3 | 0 |
| POOL-ISOLATED | 3 | 35 | 1.3 | 0.33 | 58 | 0 | 21 | 38 | 38 | 2 | 2 | 0 |
| POOL-LATERAL SCOUR | 5 | 74 | 7.8 | 0.80 | 781 | 29 | 7 | 13 | 54 | 20 | 6 | 0 |
| POOL-STRAIGHT SCOUR | 2 | 39 | 12.0 | 1.00 | 450 | 9 | 4 | 7 | 29 | 43 | 19 | 0 |
| RAPID/BOULDERS | 2 | 300 | 17.5 | 0.00 | 5,250 | 497 | 0 | 3 | 12 | 29 | 47 | 11 |
| RIFFLE | 37 | 3,199 | 15.4 | 0.00 | 53,621 | 1749 | 1 | 5 | 26 | 46 | 22 | 0 |
| RIFFLE W/ POCKETS | 10 | 684 | 14.8 | 0.00 | 11,116 | 520 | 1 | 5 | 26 | 42 | 26 | 1 |
| Total: | 91 | 5,898 | 13.1 | 0.10 | 93,569 | 3163 | Avg: 5 | 8 | 31 | 37 | 18 | 0 |

HABITAT SUMMARY

| Habitat Group | No. Units | Total Length (m) | Avg Width (m) | Avg Depth (m) | Wetted Area (m2) | Wetted Area Percent | Large Boulders Number | Large Boulders #/100m2 |
|---|---|---|---|---|---|---|---|---|
| Dammed & BW Pools | 8 | 101 | 3.0 | 0.25 | 345 | 0.37 | 3 | 0.87 |
| Scour Pools | 7 | 113 | 9.0 | 0.86 | 1231 | 1.32 | 38 | 3.09 |
| Glides | 27 | 1,501 | 13.0 | 0.04 | 22006 | 23.52 | 356 | 1.62 |
| Riffles | 47 | 3,883 | 15.2 | 0.00 | 64737 | 69.19 | 2269 | 3.50 |
| Rapids | 2 | 300 | 17.5 | 0.00 | 5250 | 5.61 | 497 | 9.47 |
| Cascades | 0 | 0 | . | . | 0 | 0.00 | 0 | 0.00 |
| Step/Falls | 0 | 0 | . | . | 0 | 0.00 | 0 | 0.00 |
| Dry | 0 | 0 | . | . | 0 | 0.00 | 0 | 0.00 |

POOL SUMMARY

| | Total | #/km |
|---|---|---|
| All Pools | 15 | 2.5 |
| Pools >1m deep: | 8 | 1.4 |
| Complex pools (wood pieces>3): | 5 | 0.8 |
| Pool frequency (channel widths/pool): | 24.6 | |

LARGE WOOD DEBRIS

| | Pieces | Pieces/100m |
|---|---|---|
| Small (>15cm dbh, 3m length) | 220 | 3.7 |
| Medium (>30cm dbh, 6m length) | 391 | 6.6 |
| Large (>60cm dbh, 10m length) | 74 | 1.3 |
| Total - all LWD classes | 685 | 11.6 |

HABITAT UNIT SUMMARY

REACH 4 REACH 4

HABITAT DETAIL

| Habitat Type | Number Units | Total Length (m) | Avg Width (m) | Avg Depth (m) | Total Area (m2) | Large Boulders (#>0.5m) | Substrate Percent Wetted Area S/O | Snd | Grvl | Cbbl | Bldr | Bdrk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GLIDE | 5 | 433 | 14.8 | 0.00 | 6,423 | 68 | 5 | 5 | 45 | 30 | 15 | 0 |
| POOL-BACKWATER | 1 | 9 | 1.0 | 0.00 | 9 | 5 | 9 | 14 | 59 | 9 | 9 | 0 |
| POOL-LATERAL SCOUR | 1 | 40 | 10.0 | 1.00 | 400 | 11 | 0 | 5 | 32 | 42 | 21 | 0 |
| RIFFLE | 5 | 284 | 14.2 | 0.00 | 3,943 | 101 | 1 | 2 | 40 | 39 | 18 | 0 |
| Total: | 12 | 766 | 13.0 | 0.08 | 10,775 | 185 | Avg: 3 | 5 | 43 | 33 | 16 | 0 |

HABITAT SUMMARY

| Habitat Group | No. Units | Total Length (m) | Avg Width (m) | Avg Depth (m) | Wetted Area (m2) | Wetted Area Percent | Large Boulders Number | Large Boulders #/100m2 |
|---|---|---|---|---|---|---|---|---|
| Dammed & BW Pools | 1 | 9 | 1.0 | 0.00 | 9 | 0.08 | 5 | 55.56 |
| Scour Pools | 1 | 40 | 10.0 | 1.00 | 400 | 3.71 | 11 | 2.75 |
| Glides | 5 | 433 | 14.8 | 0.00 | 6423 | 59.61 | 68 | 1.06 |
| Riffles | 5 | 284 | 14.2 | 0.00 | 3943 | 36.59 | 101 | 2.56 |
| Rapids | 0 | 0 | . | . | 0 | 0.00 | 0 | 0.00 |
| Cascades | 0 | 0 | . | . | 0 | 0.00 | 0 | 0.00 |
| Step/Falls | 0 | 0 | . | . | 0 | 0.00 | 0 | 0.00 |
| Dry | 0 | 0 | . | . | 0 | 0.00 | 0 | 0.00 |

POOL SUMMARY

| | Total | #/km |
|---|---|---|
| All Pools | 2 | 2.6 |
| Pools >1m deep: | 1 | 1.3 |
| Complex pools (wood pieces>3): | 0 | 0.0 |
| Pool frequency (channel widths/pool): | 547.1 | |

LARGE WOOD DEBRIS

| | Pieces | Pieces/100m |
|---|---|---|
| Small (>15cm dbh, 3m length) | 0 | 0.0 |
| Medium (>30cm dbh, 6m length) | 0 | 0.0 |
| Large (>60cm dbh, 10m length) | 0 | 0.0 |
| Total - all LWD classes | 0 | 0.0 |

STREAM SUMMARY MF MALHEUR

| Number Units | Total Length (m) | Avg Width (m) | Avg Depth (m) | Total Area (m2) | Substrate Percent Wetted Area S/O | Sand | Grvl | Cbbl | Bldr | Bdrk | Total Large Boulder |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 245 | 19,094 | 14.4 | 0.15 | 319,909 | 3 | 7 | 26 | 42 | 22 | 0 | 9,064 |

Wetted Area

| Habitat Group | (m2) | Percent |
|---|---|---|
| Scour Pool | 7,086 | 2.2 |
| Backwater Pools | 455 | 0.1 |
| Glide | 45,300 | 14.2 |
| Riffle | 241,003 | 75.3 |
| Rapid | 24,314 | 7.6 |
| Cascade | 0 | 0.0 |
| Step | 683 | 0.2 |
| Dry | 0 | 0.0 |

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REACH SUMMARY

REACH 1 T18SR34ESEC9SE
REACH 1

UTM Zone: 11

| | | | |
|---|---|---|---|
| Start: | Easting 0377484 | End: | Easting |
| | Northing 4874264 | | Northing |

Valley and Channel Summary

Valley Characteristics (Percent Reach Length)

| Narrow Valley Floor | | Broad Valley Floor | |
|---|---|---|---|
| Steep V-shape | 0 | Constraining Terraces | 0 |
| Moderate V-shape | 100 | Multiple Terraces | 0 |
| Open V-shape | 0 | Wide Floodplain | 0 |

Valley Width Index: 1

Channel Morphology (Percent Reach Length)

| Constrained | | Unconstrained | |
|---|---|---|---|
| Hillslope | 100 | Single Channel | 0 |
| Bedrock | 0 | Multiple Channel | 0 |
| Terrace | 0 | Braided Channel | 0 |
| Alt. Terrace/Hill | 0 | | |
| Landuse | 0 | | |

Channel Characteristics

| Type | Length(m) | Area (m2) | Dry Units |
|---|---|---|---|
| Primary | 10,788 | 188,728 | 0 |
| Secondary | 52 | 189 | 0 |

Channel Dimensions(m)

| Wetted | | Active | | Floodprone | |
|---|---|---|---|---|---|
| Width | 15.2 | Width | 23.0 | | 29.0 |
| Depth | 0.18 | Height | 0.7 | | 1.4 |
| | | W:D ratio | 32.9 | Entrenchment | 1.3 |

Stream Flow Type: MF Water Temp: 8C/0900
Avg. Unit Gradient: 1.7% Habitat Units/100m: 0.6

Riparian and Bank Summary

| | Primary | Secondary |
|---|---|---|
| Land Use: | | |
| Riparian Vegetation: | C | P |

Bank Condition and Shade

| Bank Status | % Reach Length | Shade (% of 180) |
|---|---|---|
| Actively Eroding | 0% | Reach avg: 61% |
| | | Range: 0- 81% |

Reach notes: USFS BOUNDARY

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REACH SUMMARY

REACH 2
REACH 2

UTM Zone: 11

| | | | |
|---|---|---|---|
| Start: | Easting | End: | Easting |
| | Northing | | Northing |

Valley and Channel Summary

Valley Characteristics (Percent Reach Length)

| Narrow Valley Floor | | Broad Valley Floor | |
|---|---|---|---|
| Steep V-shape | 0 | Constraining Terraces | 0 |
| Moderate V-shape | 100 | Multiple Terraces | 0 |
| Open V-shape | 0 | Wide Floodplain | 0 |

Valley Width Index: 1-2.5

Channel Morphology (Percent Reach Length)

| Constrained | | Unconstrained | |
|---|---|---|---|
| Hillslope | 100 | Single Channel | 0 |
| Bedrock | 0 | Multiple Channel | 0 |
| Terrace | 0 | Braided Channel | 0 |
| Alt. Terrace/Hill | 0 | | |
| Landuse | 0 | | |

Channel Characteristics

| Type | Length(m) | Area (m2) | Dry Units |
|---|---|---|---|
| Primary | 1,572 | 26,137 | 0 |
| Secondary | 70 | 700 | 0 |

Channel Dimensions(m)

| Wetted | | Active | | Floodprone | |
|---|---|---|---|---|---|
| Width | 16.3 | Width | 19.0 | | 25.0 |
| Depth | 0.24 | Height | 0.8 | | 1.6 |
| | | W:D ratio | 23.8 | Entrenchment | 1.3 |

Stream Flow Type: LF Water Temp:
Avg. Unit Gradient: 0.9% Habitat Units/100m: 1.5

Riparian and Bank Summary

| | Primary | Secondary |
|---|---|---|
| Land Use: | LG | |
| Riparian Vegetation: | C | P |

Bank Condition and Shade

| Bank Status | % Reach Length | Shade (% of 180) |
|---|---|---|
| Actively Eroding | 6% | Reach avg: 52% |
| | | Range: 39- 69% |

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REACH SUMMARY

REACH 3
REACH 3

UTM Zone: 11

Start: Easting End: Easting
Northing Northing

Valley and Channel Summary

Valley Characteristics (Percent Reach Length)

| Narrow Valley Floor | | Broad Valley Floor | |
|---|---|---|---|
| Steep V-shape | 0 | Constraining Terraces | 0 |
| Moderate V-shape | 100 | Multiple Terraces | 0 |
| Open V-shape | 0 | Wide Floodplain | 0 |

Valley Width Index: 1-2.5

Channel Morphology (Percent Reach Length)

| Constrained | | Unconstrained | |
|---|---|---|---|
| Hillslope | 100 | Single Channel | 0 |
| Bedrock | 0 | Multiple Channel | 0 |
| Terrace | 0 | Braided Channel | 0 |
| Alt. Terrace/Hill | 0 | | |
| Landuse | 0 | | |

Channel Characteristics

| Type | Length(m) | Area (m2) | Dry Units |
|---|---|---|---|
| Primary | 5,143 | 89,210 | 0 |
| Secondary | 755 | 4,359 | 0 |

Channel Dimensions(m)

| Wetted | | Active | | Floodprone | |
|---|---|---|---|---|---|
| Width | 13.1 | Width | 16.0 | | 23.0 |
| Depth | 0.10 | Height | 0.6 | | 1.3 |
| | | W:D ratio | 26.7 | Entrenchment | 1.4 |

Stream Flow Type: LF Water Temp: 62F/1220
Avg. Unit Gradient: 1.2% Habitat Units/100m: 1.5

Riparian and Bank Summary

| | Primary | Secondary |
|---|---|---|
| Land Use: | LG | |
| Riparian Vegetation: | C | P |

Bank Condition and Shade

| Bank Status | % Reach Length | Shade (% of 180) |
|---|---|---|
| Actively Eroding | 10% | Reach avg: 48% |
| | | Range: 27- 77% |

Reach notes:

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REACH SUMMARY

REACH 4
REACH 4

UTM Zone: 11

| | | | |
|---|---|---|---|
| Start: | Easting | End: | Easting |
| | Northing | | Northing |

Valley and Channel Summary

Valley Characteristics (Percent Reach Length)

| Narrow Valley Floor | | Broad Valley Floor | |
|---|---|---|---|
| Steep V-shape | 0 | Constraining Terraces | 0 |
| Moderate V-shape | 0 | Multiple Terraces | 0 |
| Open V-shape | 100 | Wide Floodplain | 0 |

Valley Width Index: 1-2.5

Channel Morphology (Percent Reach Length)

| Constrained | | Unconstrained | |
|---|---|---|---|
| Hillslope | 100 | Single Channel | 0 |
| Bedrock | 0 | Multiple Channel | 0 |
| Terrace | 0 | Braided Channel | 0 |
| Alt. Terrace/Hill | 0 | | |
| Landuse | 0 | | |

Channel Characteristics

| Type | Length(m) | Area (m2) | Dry Units |
|---|---|---|---|
| Primary | 757 | 10,766 | 0 |
| Secondary | 9 | 9 | 0 |

Channel Dimensions(m)

| Wetted | | Active | | Floodprone | |
|---|---|---|---|---|---|
| Width | 13.0 | Width | 26.7 | | 56.0 |
| Depth | 0.08 | Height | 0.7 | | 1.4 |
| | | W:D ratio | 37.14 | Entrenchment | 2.1 |

Stream Flow Type: LF    Water Temp: 20C/1723
Avg. Unit Gradient: 0.9%    Habitat Units/100m: 1.6

Riparian and Bank Summary

| | Primary | Secondary |
|---|---|---|
| Land Use: | HG | |
| Riparian Vegetation: | B | P |

Bank Condition and Shade

| Bank Status | % Reach Length | Shade (% of 180) |
|---|---|---|
| Actively Eroding | 30% | Reach avg: 20% |
| | | Range: 13- 43% |

Reach notes:

Riparian transects.

| Reach 1 | | | | | Cover (percent) | | | | Diameter class (cm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UNIT | SIDE | ZONE | SURFACE | SLOPE | CANOPY | SHRUB | GRASS | | 3-15 | 15-30 | 30-50 | 50-90 | >90 | Notes |
| 1 | LF | 1 | HS | 39.0 | 40 | 10 | 70 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | 9 | | | | | |
| 1 | LF | 2 | HS | 52.0 | 40 | 0 | 60 | CONIFER | | | | 1 | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 1 | LF | 3 | HS | 60.0 | 50 | 5 | 50 | CONIFER | | | 2 | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 1 | RT | 1 | LT | 14.0 | 80 | 90 | 5 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | 4 | | | | |
| 1 | RT | 2 | HS | 21.0 | 95 | 80 | 15 | CONIFER | 1 | | | 1 | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 1 | RT | 3 | HS | 50.0 | 85 | 10 | 75 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 30 | LF | 1 | HS | 37.0 | 15 | 35 | 60 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | 5 | | | | | |
| 30 | LF | 2 | HS | 15.0 | 70 | 15 | 75 | CONIFER | 2 | | | | 1 | |
| | | | | | | | | HARDWOOD | | | | | | |
| 30 | LF | 3 | HS | 10.0 | 40 | 15 | 65 | CONIFER | 1 | 1 | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 30 | RT | 1 | HS | 34.0 | 40 | 30 | 40 | CONIFER | 1 | | | | | |
| | | | | | | | | HARDWOOD | 4 | | | | | |
| 30 | RT | 2 | HS | 35.0 | 90 | 15 | 50 | CONIFER | | | 2 | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 30 | RT | 3 | HS | 39.0 | 50 | 20 | 25 | CONIFER | | | | 1 | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 60 | LF | 1 | HT | 1.0 | 60 | 80 | 20 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | 2 | | | | | |
| 60 | LF | 2 | HT | 0.0 | 5 | 60 | 30 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | 1 | | | | | |
| 60 | LF | 3 | HT | 1.0 | 10 | 69 | 20 | CONIFER | 2 | | | | | |
| | | | | | | | | HARDWOOD | 3 | | | | | |
| 60 | RT | 1 | HS | 72.0 | 5 | 15 | 20 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | 2 | | | | | |
| 60 | RT | 2 | HS | 70.0 | 30 | 40 | 35 | CONIFER | 2 | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 60 | RT | 3 | HS | 58.0 | 55 | 20 | 60 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 90 | LF | 1 | FP | 0.0 | 20 | 20 | 70 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 90 | LF | 2 | HS | 9.0 | 40 | 5 | 55 | CONIFER | 4 | 1 | 1 | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 90 | LF | 3 | HS | 17.0 | 30 | 10 | 60 | CONIFER | 9 | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 90 | RT | 1 | HS | 55.0 | 0 | 0 | 0 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | ROCKSLIDE |
| 90 | RT | 2 | HS | 55.0 | 0 | 0 | 0 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | ROCKSLIDE |
| 90 | RT | 3 | HS | 55.0 | | | | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | ROCKSLIDE |

Riparian transects.

| Reach 2 | | | | | Cover (percent) | | | | Diameter class (cm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UNIT | SIDE | ZONE | SURFACE | SLOPE | CANOPY | SHRUB | GRASS | | 3-15 | 15-30 | 30-50 | 50-90 | >90 | Notes |
| 120 | LF | 1 | HS | 40.0 | 80 | 25 | 65 | CONIFER | 3 | 4 | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 120 | LF | 2 | HS | 62.0 | 50 | 20 | 50 | CONIFER | 2 | | | | 1 | |
| | | | | | | | | HARDWOOD | | | | | | |
| 120 | LF | 3 | HS | 70.0 | 20 | 10 | 55 | CONIFER | | 1 | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 120 | RT | 1 | HS | 45.0 | 15 | 15 | 60 | CONIFER | | | 1 | 0 | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 120 | RT | 2 | HS | 41.0 | 55 | 5 | 50 | CONIFER | 2 | 4 | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 120 | RT | 3 | HS | 45.0 | 70 | 5 | 35 | CONIFER | 1 | 1 | 1 | | | |
| | | | | | | | | HARDWOOD | | | | | | |

| Reach 3 | | | | | Cover (percent) | | | | Diameter class (cm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UNIT | SIDE | ZONE | SURFACE | SLOPE | CANOPY | SHRUB | GRASS | | 3-15 | 15-30 | 30-50 | 50-90 | >90 | Notes |
| 150 | LF | 1 | HS | 30.0 | 0 | 5 | 10 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 150 | LF | 2 | HS | 62.0 | 0 | 5 | 0 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 150 | LF | 3 | HS | 120.0 | 0 | 15 | 5 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 150 | RT | 1 | HS | 44.0 | | 25 | 10 | CONIFER | 1 | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 150 | RT | 2 | HS | 80.0 | 0 | 10 | 5 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 150 | RT | 3 | HS | 51.0 | 0 | 10 | 5 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 180 | LF | 1 | HS | 35.0 | 10 | 5 | 35 | CONIFER | 6 | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 180 | LF | 2 | HS | 46.0 | 20 | 5 | 55 | CONIFER | | 1 | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 180 | LF | 3 | HS | 60.0 | 15 | 5 | 60 | CONIFER | | 1 | 1 | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 180 | RT | 1 | HS | 22.0 | 15 | 5 | 35 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 180 | RT | 2 | HS | 52.0 | 5 | 5 | 35 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 180 | RT | 3 | HS | 55.0 | 20 | 5 | 20 | CONIFER | | 1 | 1 | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 210 | LF | 1 | HS | 28.0 | 0 | 20 | 20 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 210 | LF | 2 | HS | 16.0 | 0 | 30 | 5 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 210 | LF | 3 | HS | 20.0 | 15 | 15 | 2 | CONIFER | | | 2 | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 210 | RT | 1 | HS | 30.0 | 40 | 15 | 55 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 210 | RT | 2 | HS | 52.0 | 40 | 2 | 40 | CONIFER | 1 | | | | | |

Riparian transects.

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | HARDWOOD | | | | | | |
| 210 | RT | 3 | HS | 62.0 | 0 | 5 | 5 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |

| Reach 4 | | | | | Cover (percent) | | | | Diameter class (cm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UNIT | SIDE | ZONE | SURFACE | SLOPE | CANOPY | SHRUB | GRASS | | 3-15 | 15-30 | 30-50 | 50-90 | >90 | Notes |
| 240 | LF | 1 | FP | 4.0 | 0 | 5 | 90 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 240 | LF | 2 | HS | 19.0 | 65 | 0 | 50 | CONIFER | | 3 | 1 | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 240 | LF | 3 | HS | 47.0 | 90 | 0 | 50 | CONIFER | 2 | 4 | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 240 | RT | 1 | FP | 4.0 | 0 | 5 | 90 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 240 | RT | 2 | HS | 19.0 | 0 | 30 | 55 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 240 | RT | 3 | HS | 45.0 | 0 | 25 | 25 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 250 | LF | 1 | HT | 8.0 | 0 | 25 | 50 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 250 | LF | 2 | HT | 3.0 | 0 | 20 | 50 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 250 | LF | 3 | HS | 4.0 | 0 | 80 | 5 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 250 | RT | 1 | FP | 1.0 | 0 | 0 | 90 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 250 | RT | 2 | HS | 7.0 | 0 | 10 | 85 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |
| 250 | RT | 3 | HS | 29.0 | 0 | 55 | 5 | CONIFER | | | | | | |
| | | | | | | | | HARDWOOD | | | | | | |

Codes:
Sides:
LF – Left side
RT – Right side
Surface:
HS – Hillslope LT – Low Terrace
HT – High Terrace FP – Floodplain

**Appendix B.**

Statistical tables produced from Microsoft Excel. Tables test for significant changes of temperature between temperature probe sites. Rates of temperature change per kilometer from July 1 to September 2, 2000 were statistically compared between sites to determine if temperature sites recorded a significant rate of stream temperature change.

## Site 4 versus 3

**Parameters**

| | | | |
|---|---|---|---|
| Analysis | 2 Sample t | Ho: Mean Diff. = 0 | 0 |
| Input Column 1 | Variable 1 | Ha: Not equal to 0 | 0 |
| Input Column 2 | Variable 1 | Confidence | 0.95 |
| | | Pooled Variance | TRUE |

**Descriptive Statistics**

| | N | Mean | Std. Dev. | Std. Err. |
|---|---|---|---|---|
| Variable 1 | 62 | 0.28463343 | 0.099202443 | 0.012598723 |
| Variable 1 | 62 | 0.08656426 | 0.102806273 | 0.013056410 |

**t-Test Analysis**

| Mean Diff. | Std. Err. | t | df | p-value | lower 95% | upper 95% |
|---|---|---|---|---|---|---|
| 0.19806917 | 0.018143805 | 10.917 | 122.00 | 8.9816E-20 | 0.16215167 | 0.23398668 |

## Site 3 versus 1

**Parameters**

| | | | |
|---|---|---|---|
| Analysis | 2 Sample t | Ho: Mean Diff. = 0 | |
| Input Column 1 | Variable 1 | Ha: Not equal to 0 | |
| Input Column 2 | Variable 1 | Confidence | 0.95 |
| | | Pooled Variance | TRUE |

**Descriptive Statistics**

| | N | Mean | Std. Dev. | Std. Err. |
|---|---|---|---|---|
| Variable 1 | 62 | 0.08656426 | 0.102806273 | 0.013056410 |
| Variable 1 | 62 | 0.0683669 | 0.06164896 | 0.00782943 |

**t-Test Analysis**

| Mean Diff. | Std. Err. | t | df | p-value | lower 95% | upper 95% |
|---|---|---|---|---|---|---|
| 0.01819732 | 0.015223985 | 1.195 | 122.00 | 0.234 | -0.01194010 | 0.04833475 |

## Site 4 versus 1

**Parameters**

| | | | |
|---|---|---|---|
| Analysis | 2 Sample t | Ho: Mean Diff. = 0 | 0 |
| Input Column 1 | Variable 1 | Ha: Not equal to 0 | 0 |
| Input Column 2 | Variable 1 | Confidence | 0.95 |
| | | Pooled Variance | TRUE |

**Descriptive Statistics**

| | N | Mean | Std. Dev. | Std. Err. |
|---|---|---|---|---|
| Variable 1 | 62 | 0.28463343 | 0.099202443 | 0.012598723 |
| Variable 1 | 62 | 0.0683669 | 0.06164896 | 0.00782943 |

**t-Test Analysis**

| Mean Diff. | Std. Err. | t | df | p-value | lower 95% | upper 95% |
|---|---|---|---|---|---|---|
| 0.21626650 | 0.014833331 | 14.580 | 122.00 | 1.693E-28 | 0.18690241 | 0.24563058 |

## Site 4 versus 2

**Parameters**

| | | | |
|---|---|---|---|
| Analysis | 2 Sample t | Ho: Mean Diff. = 0 | 0 |
| Input Column 1 | Variable 1 | Ha: Not equal to 0 | 0 |
| Input Column 2 | Variable 1 | Confidence | 0.95 |
| | | Pooled Variance | TRUE |

**Descriptive Statistics**

| | N | Mean | Std. Dev. | Std. Err. |
|---|---|---|---|---|
| Variable 1 | 62 | 0.28463343 | 0.099202443 | 0.012598723 |
| Variable 1 | 62 | 1.80304659 | 0.785238970 | 0.099725449 |

**t-Test Analysis**

| Mean Diff. | Std. Err. | t | df | p-value | lower 95% | upper 95% |
|---|---|---|---|---|---|---|
| -1.51841316 | 0.100518123 | -15.106 | 122.00 | 1.0343E-29 | -1.71739900 | -1.31942733 |

## Site 3 versus 2

**Parameters**

| | | | |
|---|---|---|---|
| Analysis | 2 Sample t | Ho: Mean Diff. = 0 | 0 |
| Input Column 1 | Variable 1 | Ha: Not equal to 0 | 0 |
| Input Column 2 | Variable 1 | Confidence | 0.95 |
| | | Pooled Variance | TRUE |

**Descriptive Statistics**

| | N | Mean | Std. Dev. | Std. Err. |
|---|---|---|---|---|
| Variable 1 | 62 | 0.08656426 | 0.102806273 | 0.013056410 |
| Variable 1 | 62 | 1.80304659 | 0.785238970 | 0.099725449 |

**t-Test Analysis**

| Mean Diff. | Std. Err. | t | df | p-value | lower 95% | upper 95% |
|---|---|---|---|---|---|---|
| -1.71648233 | 0.100576513 | -17.066 | 122.00 | 4.0786E-34 | -1.91558376 | -1.51738091 |

## Site 2 versus 1

**Parameters**

| | | | |
|---|---|---|---|
| Analysis | 2 Sample t | Ho: Mean Diff. = 0 | 0 |
| Input Column 1 | Variable 1 | Ha: Not equal to 0 | 0 |
| Input Column 2 | Variable 1 | Confidence | 0.95 |
| | | Pooled Variance | TRUE |

**Descriptive Statistics**

| | N | Mean | Std. Dev. | Std. Err. |
|---|---|---|---|---|
| Variable 1 | 62 | 0.0683669 | 0.06164896 | 0.00782943 |
| Variable 1 | 62 | 1.80304659 | 0.785238970 | 0.099725449 |

**t-Test Analysis**

| Mean Diff. | Std. Err. | t | df | p-value | lower 95% | upper 95% |
|---|---|---|---|---|---|---|
| -1.7346797 | 0.10003232 | -17.341 | 122.00 | 1.0217E-34 | -1.9327038 | -1.5366555 |

# Upper Malheur River Water Quality and Bull Trout

Author: Steve Namitz, Burns Paiute Fish and Wildlife Department, Burns, Oregon

## Introduction

The Burns Paiute Tribe (BPT), United States Forest Service (USFS), and Oregon Department of Fish and Wildlife (ODFW), participated in documenting temperature trends in the Upper Malheur River. Bull trout *Salvenlinus confluentus* have specific environmental requirements and complex life histories making them especially susceptible to human activities that alter their habitat (Howell and Buchanan 1992). Bull trout are considered to be a cold-water species and are temperature dependent. This presents a challenge for managers, biologists, and private landowners in the Malheur River basin. The results of this paper are based on data temperature data collected in the year 2000 field season. Efforts to document water quality conditions will continue in fiscal year 2001.

**Project #:** 199701900

**Objective 3**. Monitor water quality within the Malheur Subbasin.

**Task 3.a -** Continue using thermographs to gather data on established sites.

## Methods

The Burns Paiute Tribe strategically placed 9 temperature logger units within the Upper Malheur River. One of the probes received some damage and the data was not retrievable (the probe that was placed at the BPT fish weir at the Burnt Bridge Crossing). The Tribe focused most of their efforts on the Upper Malheur River above Warm Springs Reservoir. Recently purchased lands by the Tribe in the Logan Valley are actively managed for riparian and wetland restoration. The Tribe has rested these lands from cattle grazing since April, 2000. Stream temperature data was also gathered from the ODFW, and the USFS to comprise an effort of 22 functioning temperature logger units in the Upper Malheur River.

The most commonly used technique for gathering water temperature is the use of continuous data recorders. The Tribe uses a combination of Hobo XT's and Stow Away data loggers. Loggers were calibrated for accuracy using methods recommended by Oregon's "Water Quality Monitoring Guide Book" version 2.0 (http://www.oweb.state.or.us/publications/mon_guide99.shtml). Recorders were then placed in a stable housing with the purpose of withstanding high flows and certain degrees of bed load movement. Probes are placed into streams in late spring or as access permits. There is little to no maintenance required for either of the apparatuses, as long as they stay watertight.  The probes are collected at the end of the season and the data is downloaded on to a computer database to be analyzed.

Temperature data will be analyzed based on daily maximum temperatures averaged over seven day spans.  Once water temperature data is analyzed the results will be correlated with salmonids life history and the Department of Environmental Quality's  (Oregon DEQ) current standards for water quality within the Upper Malheur River.

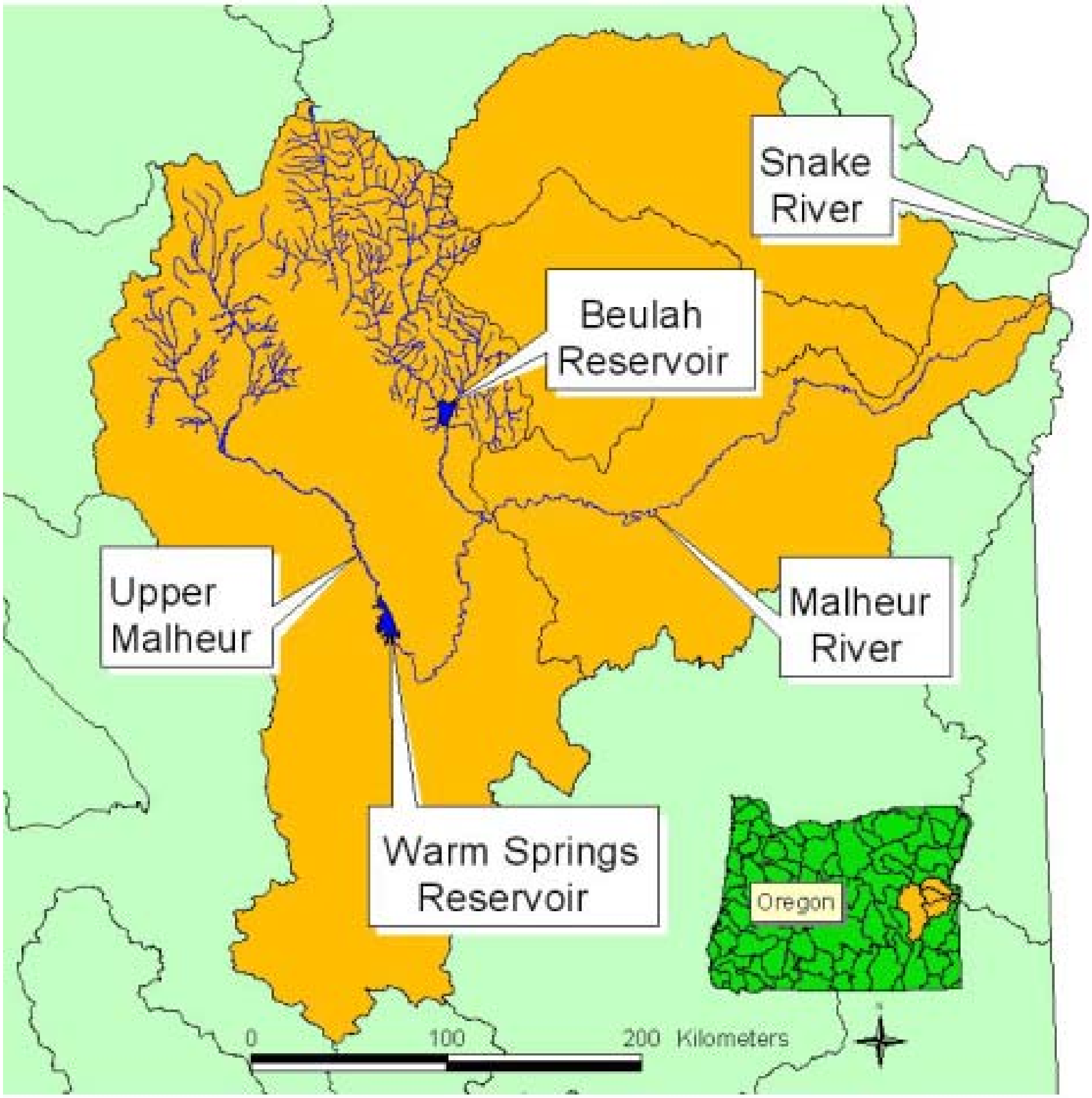


**Figure 1.** Malheur Subbasin 2000

# Results

The Upper Malheur River above Warm Springs Reservoir and most tributaries are on Oregon's Final 1998 303(d) list (Figures 2&3)(Appendix A). Waters in the Malheur are considered to be water quality limited. The Upper Malheur River is characterized as being a priority one area, with temperature being the major limiting factor for native salmonid production and distribution (DEQ 1998).

The BPT and other cooperating agencies had a total of 22 continuous data loggers in the Upper Malheur River (Table 1). The focus area was broken up into six areas or reaches to make it easier to analyze the data.

**Table 1.** Data Recorder Locations 2000

| Continuous Data Recorder | | | Location (UTM Zone 11) | |
|---|---|---|---|---|
| Probe | River Kilometer | DEQ Parameter | East | North |
| Malheur River #1 (BPT) | 306 | 1 | 370083 | 4888999 |
| Malheur River #2 (BPT) | 301 | 1 | 371907 | 4884876 |
| Malheur River #3 (USFS) | 297 | 1 | 373610 | 4882537 |
| Malheur River #4 (BPT) | 296 | 1 | 373903 | 4882112 |
| Malheur River #5 (BPT) | 285 | 1 | 377421 | 4872433 |
| Big Creek #1 (USFS) | 12 | 1 | 371376 | 4899712 |
| Big Creek #2 (USFS) | 11 | 1 | 371377 | 4899783 |
| Big Creek #3 (ODFW) | 7 | 1 | 370935 | 4896360 |
| Big Creek #4 (ODFW) | 4 | 1 | 370999 | 4892975 |
| Big Creek #5 (BPT) | 4 | 1 | 370930 | 4892673 |
| Big Creek #6 (BPT) | 2 | 1 | 370842 | 4891072 |
| Meadow Fork Creek #1 (ODFW) | 2 | 1 | 369753 | 4899548 |
| Meadow Fork Creek #2 (ODFW) | 0 | 1 | 370475 | 4898306 |
| Lake Creek #1 (USFS) | 12 | 1 | 369192 | 4898931 |
| Lake Creek #2 (ODFW) | 9.5 | 1 | 369123 | 4896665 |
| Lake Creek #3 (ODFW) | 5 | 1 | 368027 | 4892765 |
| Lake Creek #4 (ODFW) | 5 | 1 | 368204 | 4892755 |
| Lake Creek #5 (BPT) | 4 | 1 | 367885 | 4891695 |
| Lake Creek #6 (BPT) | 1 | 1 | 369389 | 4889745 |
| McCoy Creek #1 (ODFW) | 6.5 | 2 | 366675 | 4897254 |
| McCoy Creek #2 (ODFW) | 1 | 2 | 367147 | 4892777 |
| Crooked Creek (USFS) | 2 | 2 | 367614 | 4889901 |

DEQ parameters (DEQ 1998):

1. 10° C or less for bull trout.
2. 17.8° C or less for native salmonids spawning, egg incubation, and fry emergence

Temperature data was compiled and sorted to show seven-day average maximum temperatures for the summer and early fall of 2000. Data will also be correlated to the historical life history of bull trout in the Upper Malheur River.

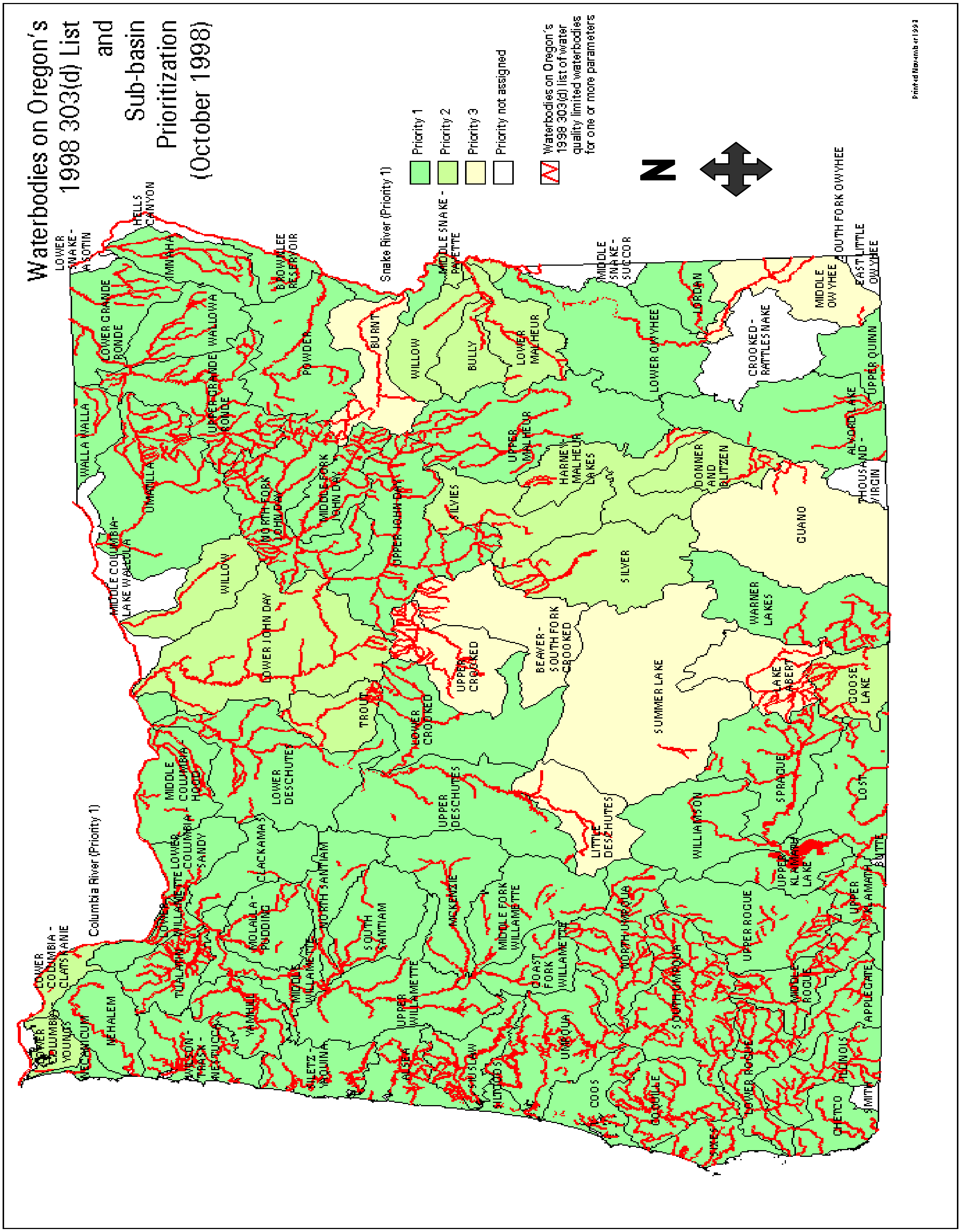


**Figure 2.** 1998 303(d) Water bodies Map (DEQ 1998) for Oregon.

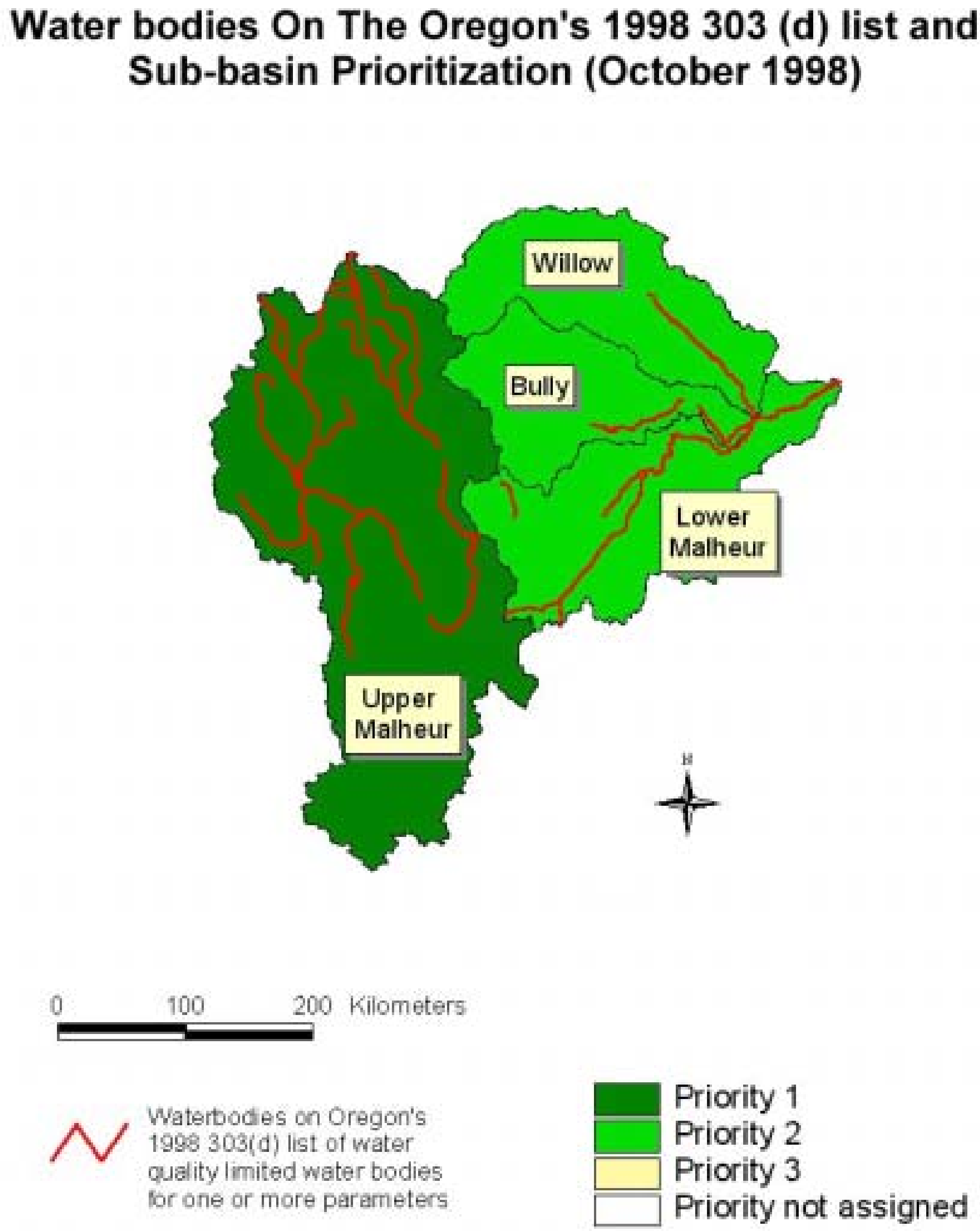


**Figure 3.** Malheur Basin 303(d) Map (DEQ 1998)

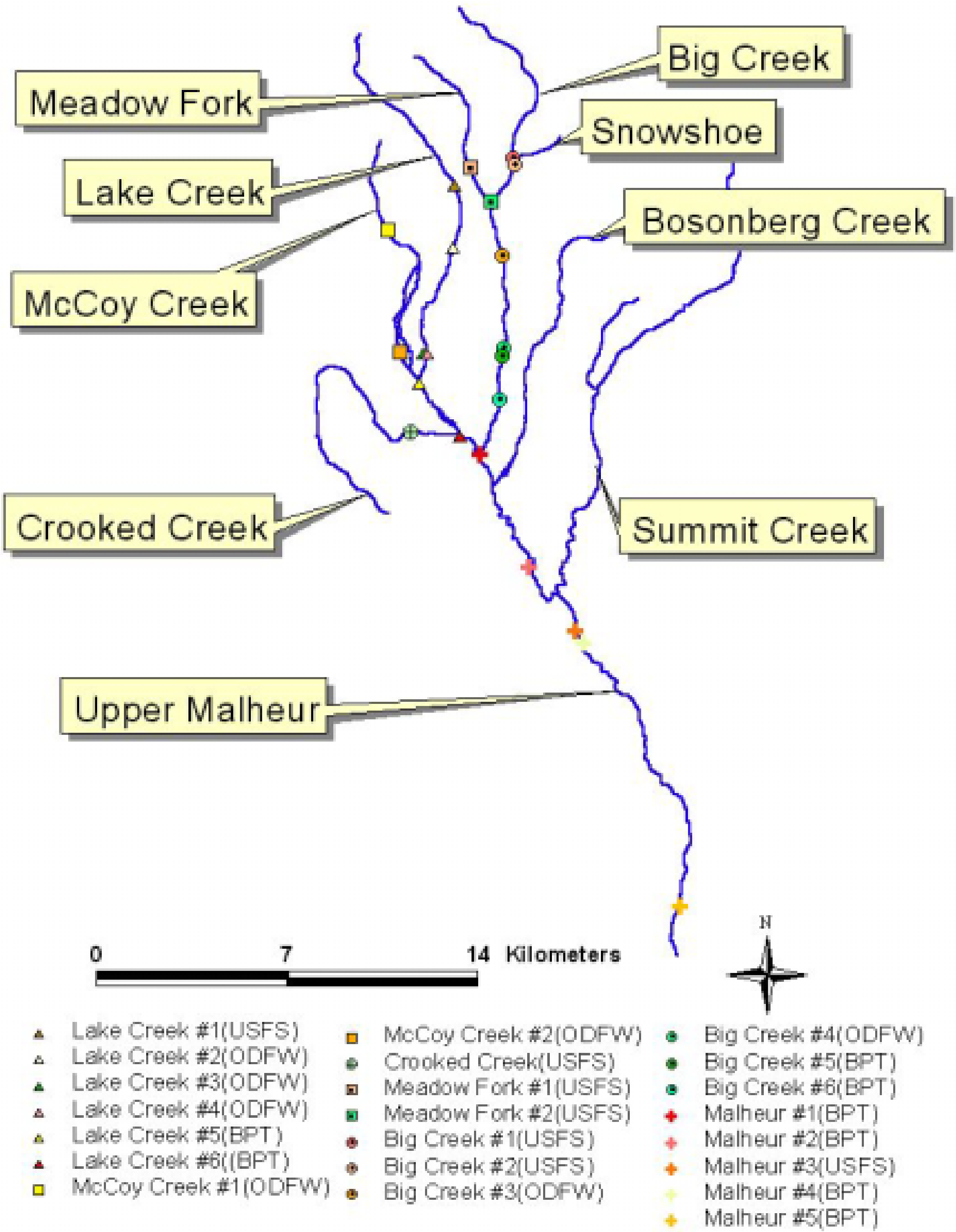


**Figure 4.** Upper Malheur River Temperature Probe Location Map 2000.

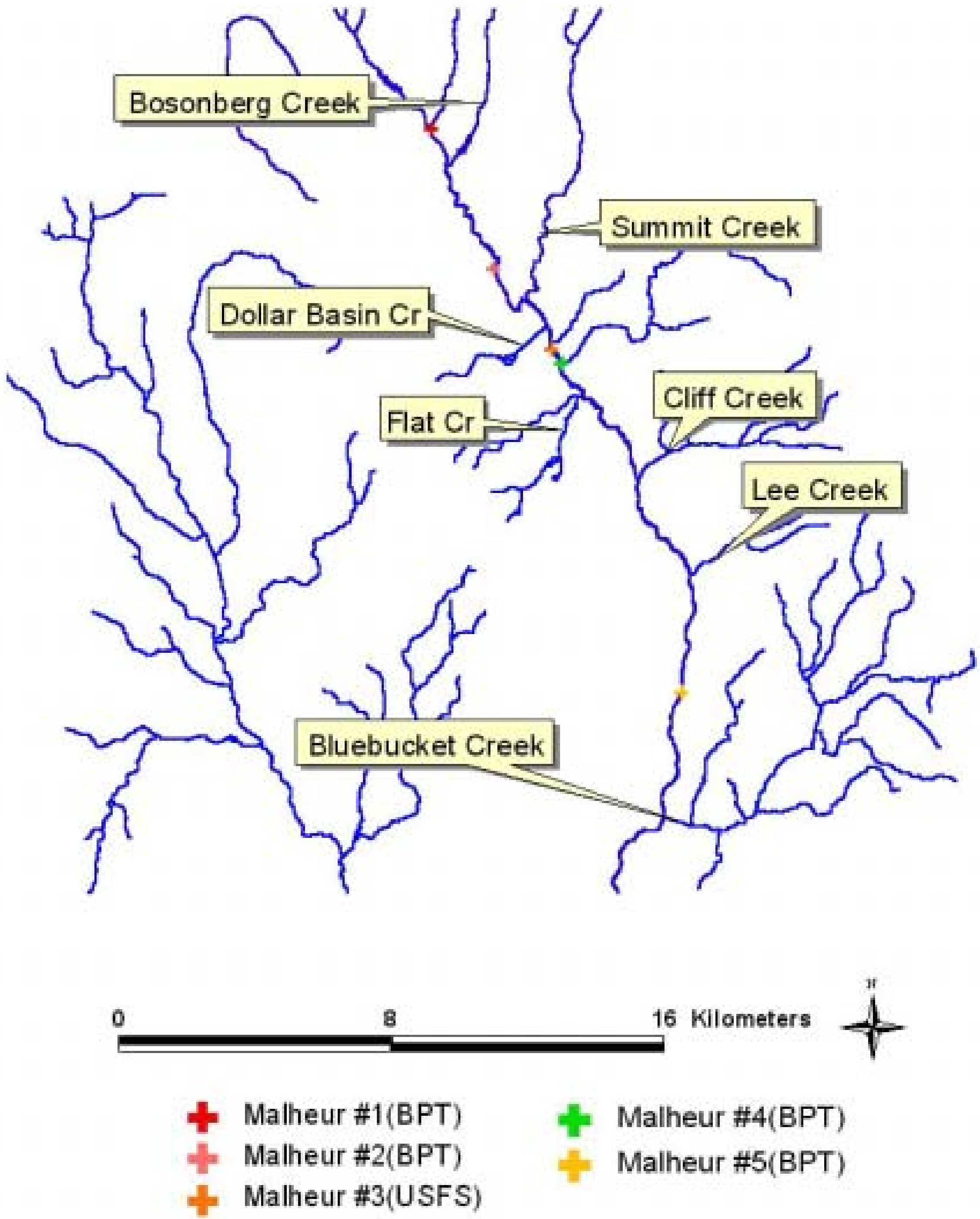


**Figure 5.** Temperature Probe Location Map for Upper Malheur River 2000

## ***Upper Malheur River:***

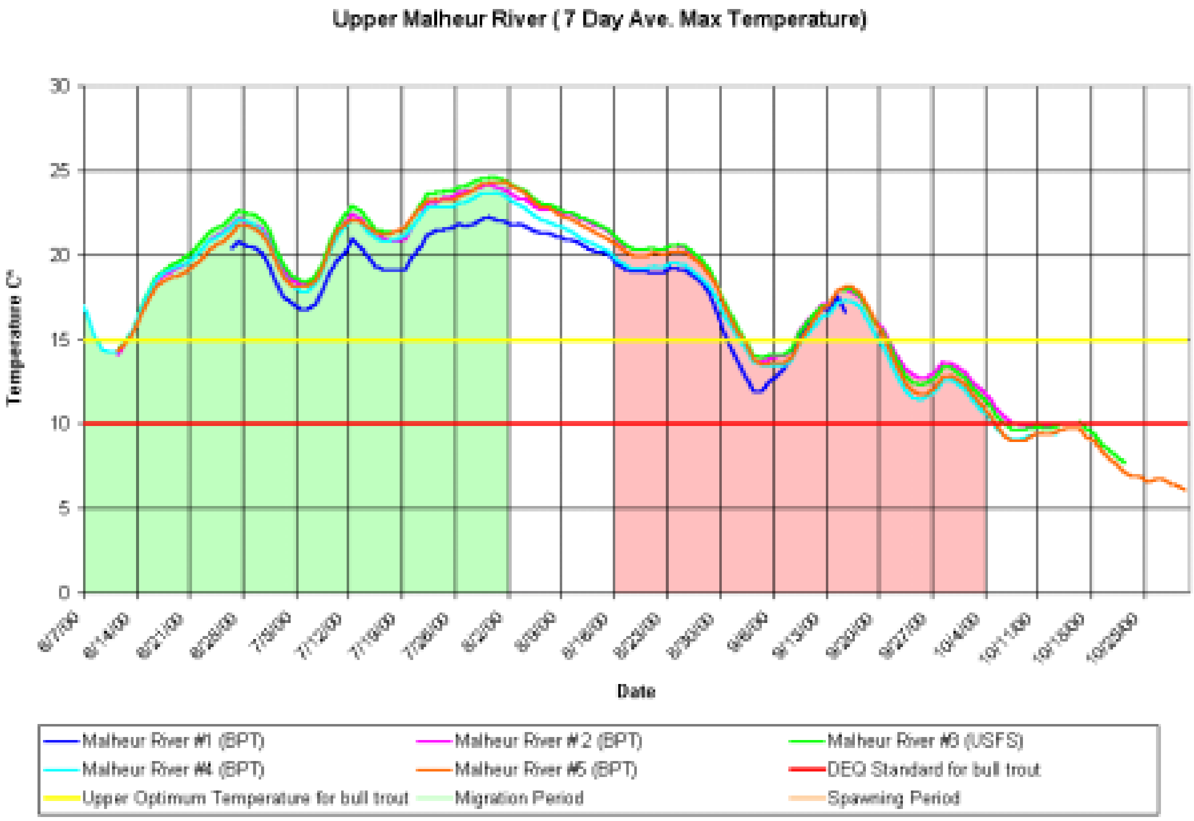


**Figure 6.** Comparison of the 7-day average maximum temperatures for the Upper Malheur River with DEQ standards and migration/spawning periods for bull trout in the Upper Malheur River 2000.

The Upper Malheur River flows into Warm Springs Reservoir at RK 208 (Oregon Water Resources Department 1983). There were five probes placed in the Upper Malheur River in the late spring of 2000 between RK 283-306 (Figure 5). Figure 5 is based on daily maximum temperatures averaged over seven day spans. According to the standards established by DEQ in 1998 temperatures at all locations peaked above the acceptable limits for bull trout. Temperatures also exceeded the upper optimum levels for adult bull trout (15° C), and optimum juvenile growth at 4 to 10° C (McPhail and Murray 1979, Shepard et al 1984, Buckman et al 1992, Ratliff 1992, Buchanan and Gregory 1997). Acceptable water temperatures for spawning bull trout are to be less than 10° C (McPhail and Murray 1979, Shepard et al 1984, Buckman et al 1992, Ratliff 1992, Buchanan and Gregory 1997). Although bull trout were present throughout the Upper Malheur River no assumptions were made as to their health or survival from the temperature trends observed. Temperatures in the Upper Malheur River exceeded the thresholds established for bull trout until roughly October 2000 after peak spawning had occurred (page 30).

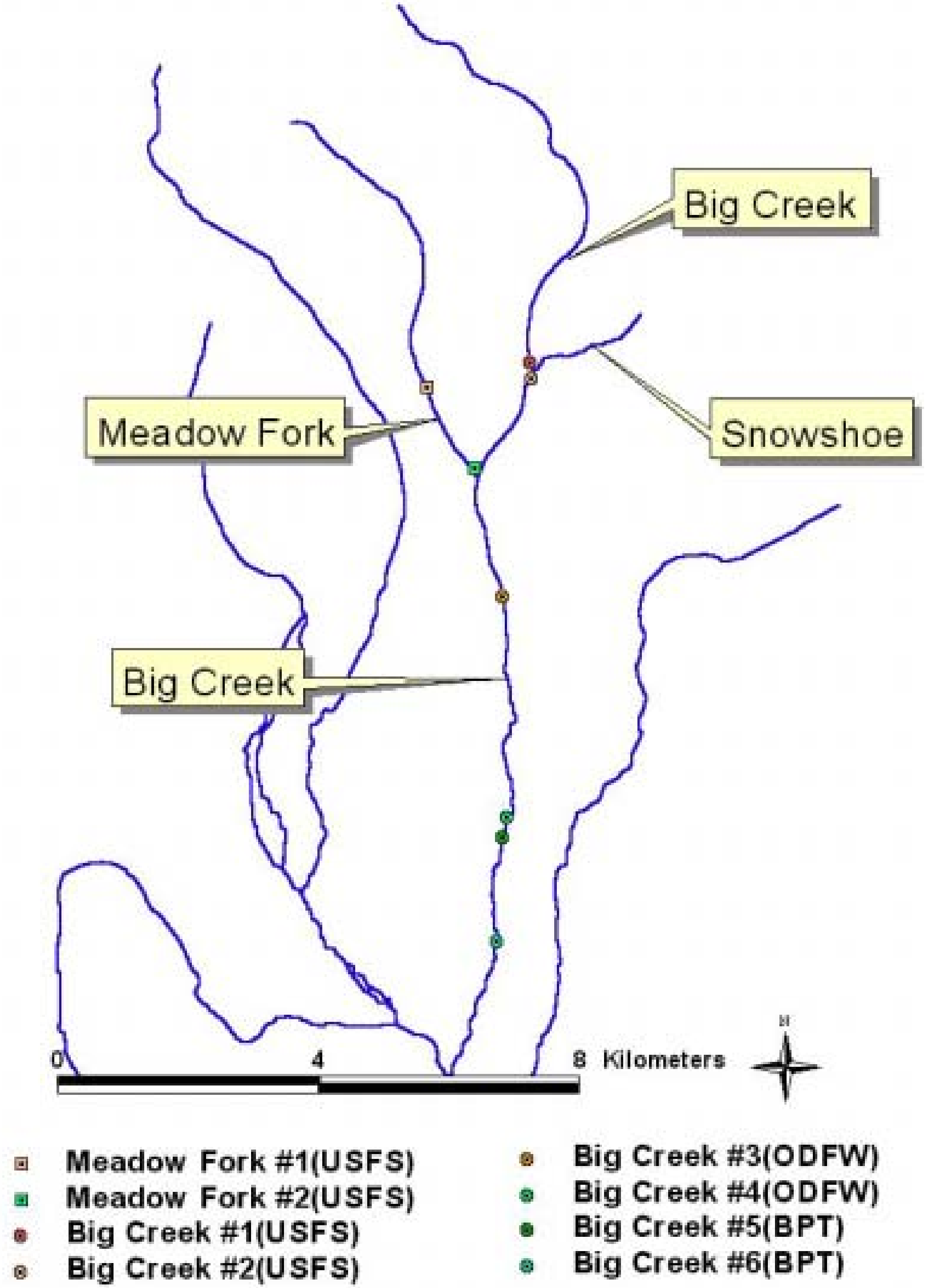


**Figure 7.** Temperature Probe Location Map for Big and Meadow Fork Creeks 2000.

## ***Big Creek:***

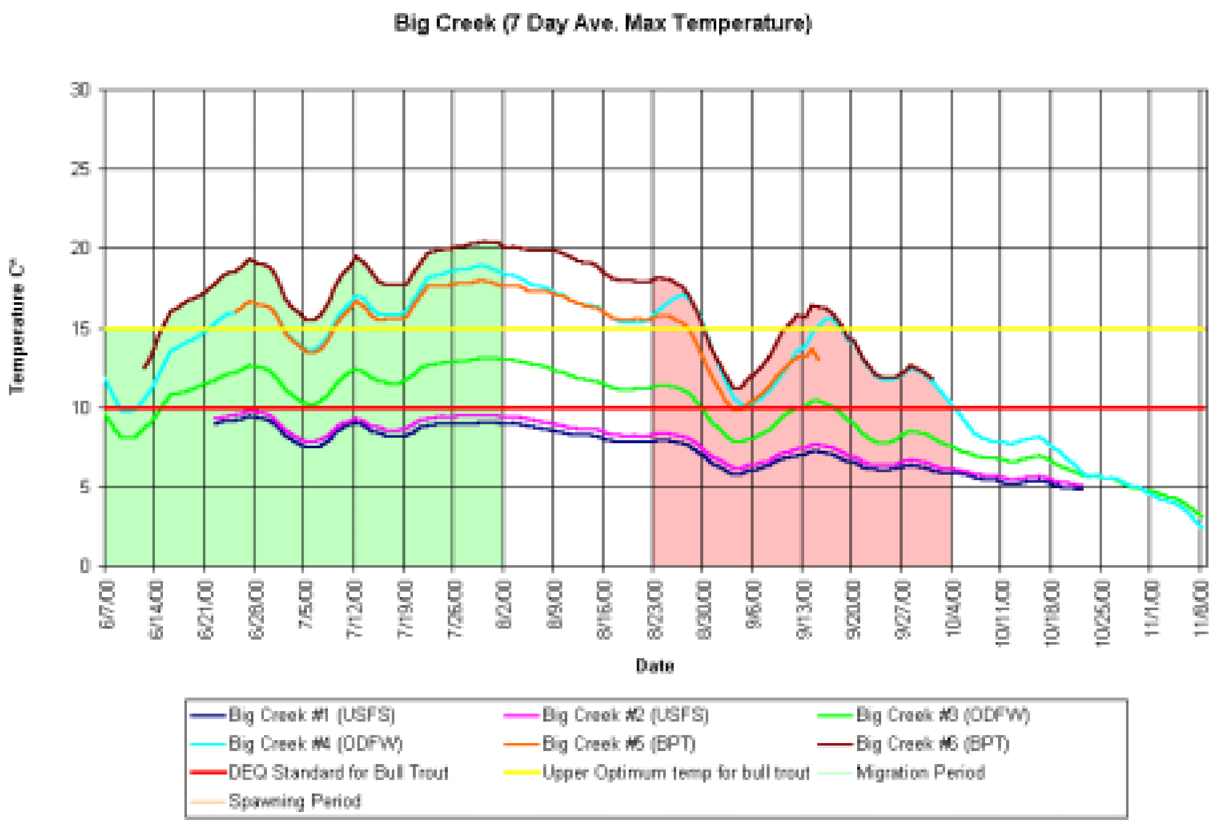


**Figure 8.** Comparison of the 7-day average maximum temperatures for Big Creek with DEQ standards and migration/spawning periods for bull trout in the Upper Malheur River 2000.

Big Creek is a tributary of the Upper Malheur River entering in at RK 306 or RK 0 (Oregon Water Resources Department 1983). Six probes were placed in Big Creek between RK 0 and 16 (Figure 7). Figure 8 is based on daily maximum temperatures averaged over seven day spans. The graph depicts what would be expected in a normal system, as waters are usually coolest in the headwaters and increase in temperature as the stream drops in elevation. Temperatures exceeded DEQ standards for bull trout in most reaches. Bull trout were present throughout Big Creek in late spring, and fish were observed in all reaches of Big Creek throughout the summer season (page 9). Although bull trout were present throughout Big Creek no assumptions were made as to their health or survival from the temperature trends observed.

## *Meadow Fork Creek:*

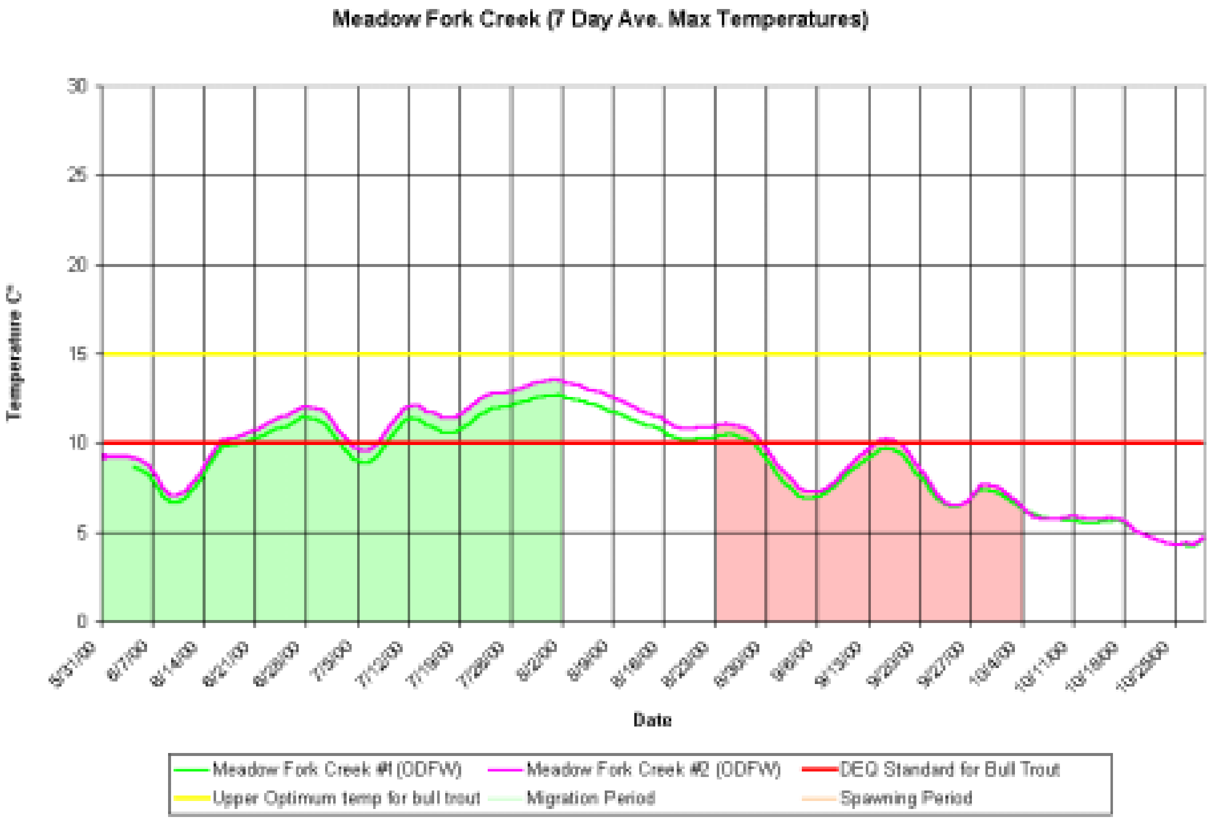


**Figure 9.** Comparison of the 7-day average maximum temperatures for Meadow Fork Creek with DEQ standards and migration/spawning periods for bull trout in the Upper Malheur basin 2000.

Meadow Fork Creek is a tributary of Big Creek flowing in at RK 16 (Figure 7). Meadow Fork Creek is considered a headwater stream and lies within the ownership of the USFS, Prairie City Ranger District. Average temperatures for 2000 in Meadow Fork were below the upper optimum temperature for bull trout but exceeded the DEQ standards (10$^{o}$ C). For periods when temperatures were above the DEQ standards they were still below the upper optimum temperatures for adult bull trout. Temperatures were generally below the standards established for bull trout spawning (10$^{o}$ C) with two peaks not exceeding 11$^{o}$ C. The BPT established that the Majority of bull trout spawning within the Upper Malheur River is occurring in Meadow Fork Creek. This was determined with the use of radio telemetery and spawning surveys conducted by the Tribe and ODFW over the past several years (Page 9 & 30).

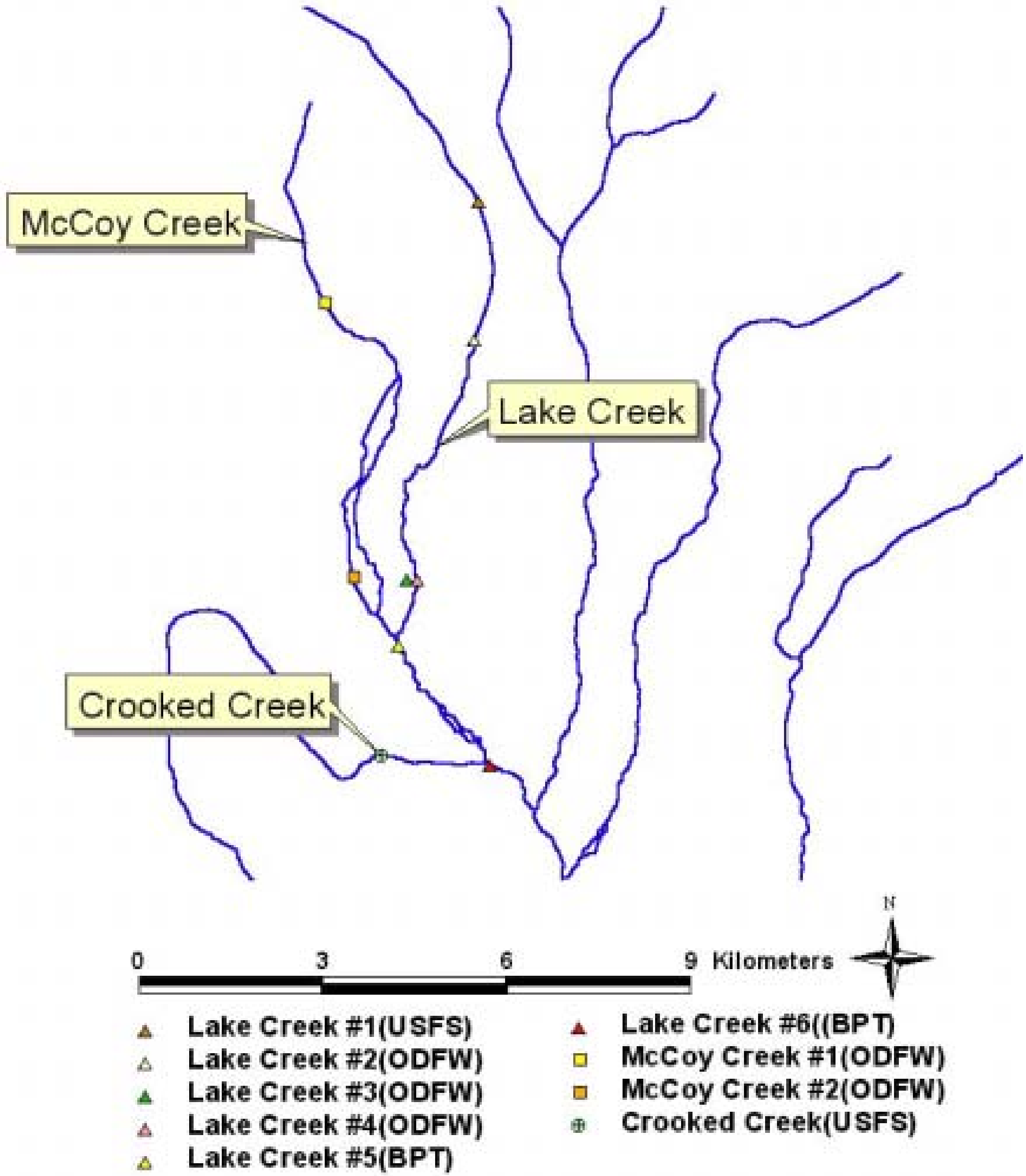


**Figure 10.** Temperature Probe Location Map for Lake, Crooked and McCoy Creeks 2000.

***Lake Creek:***

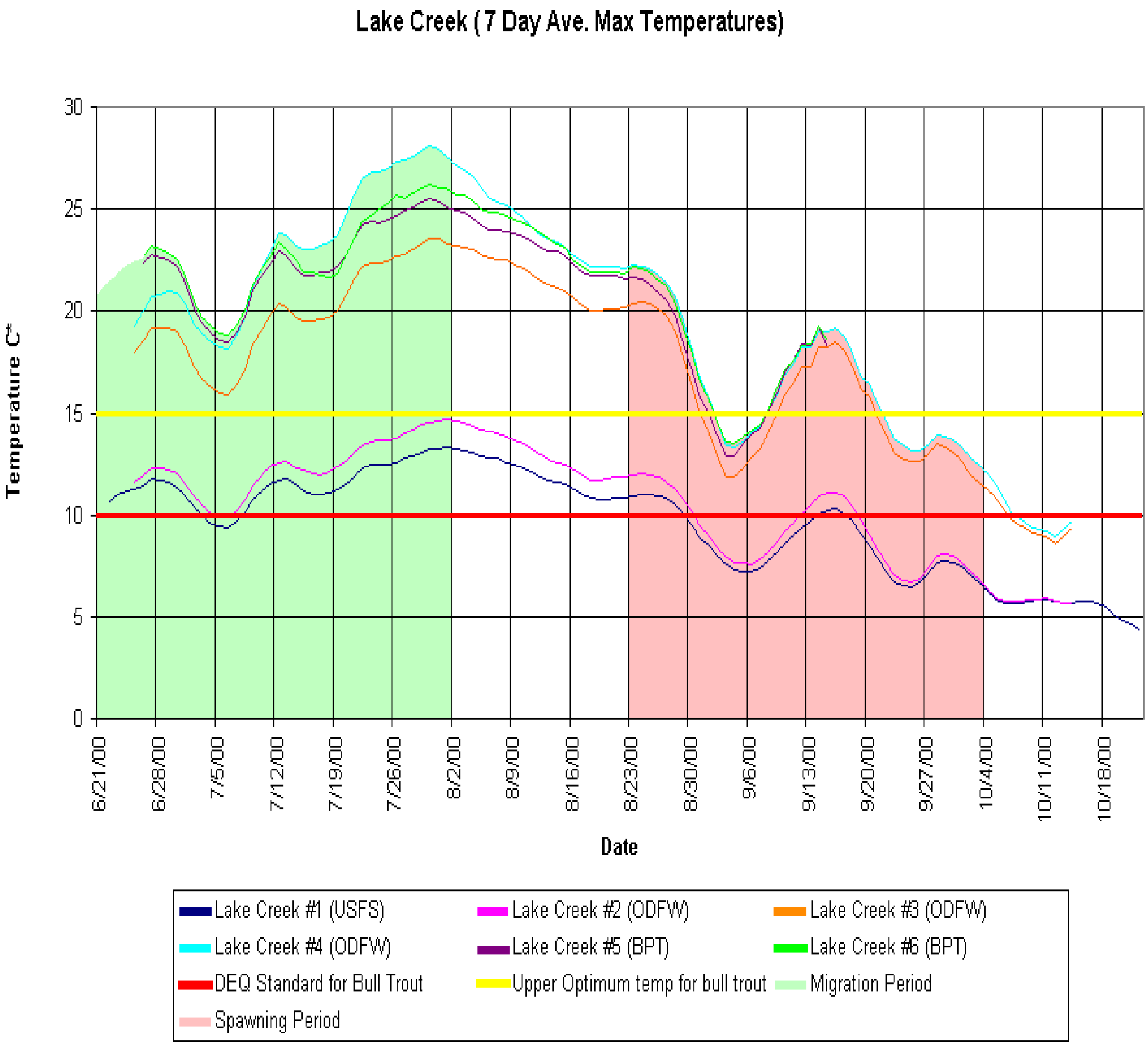


**Figure 11.** Comparison of the 7-day average maximum temperatures for Lake Creek with DEQ standards and migration/spawning periods for bull trout in the Upper Malheur basin.

Lake Creek is a tributary to the Upper Malheur River entering in at RK 0 (Oregon Water Resources Department 1983). Six probes were placed in Lake Creek between RK 0 and 19 (Figure 10). Figure 11 is based on daily maximum temperatures averaged over seven day spans. The above graph dictates temperature trends in Lake Creek for 2000. Water temperatures were coolest in the headwaters and increase as the stream drops in elevation with the exception of probe #3, which was put in East Fork Lake Creek. Bull trout have been documented in Lake Creek by ODFW (Bowers 1993, Perkins 1998) but it is feared by local managers that the bull trout within Lake Creek are being out competed for resources by brook trout.

***Crooked Creek:***

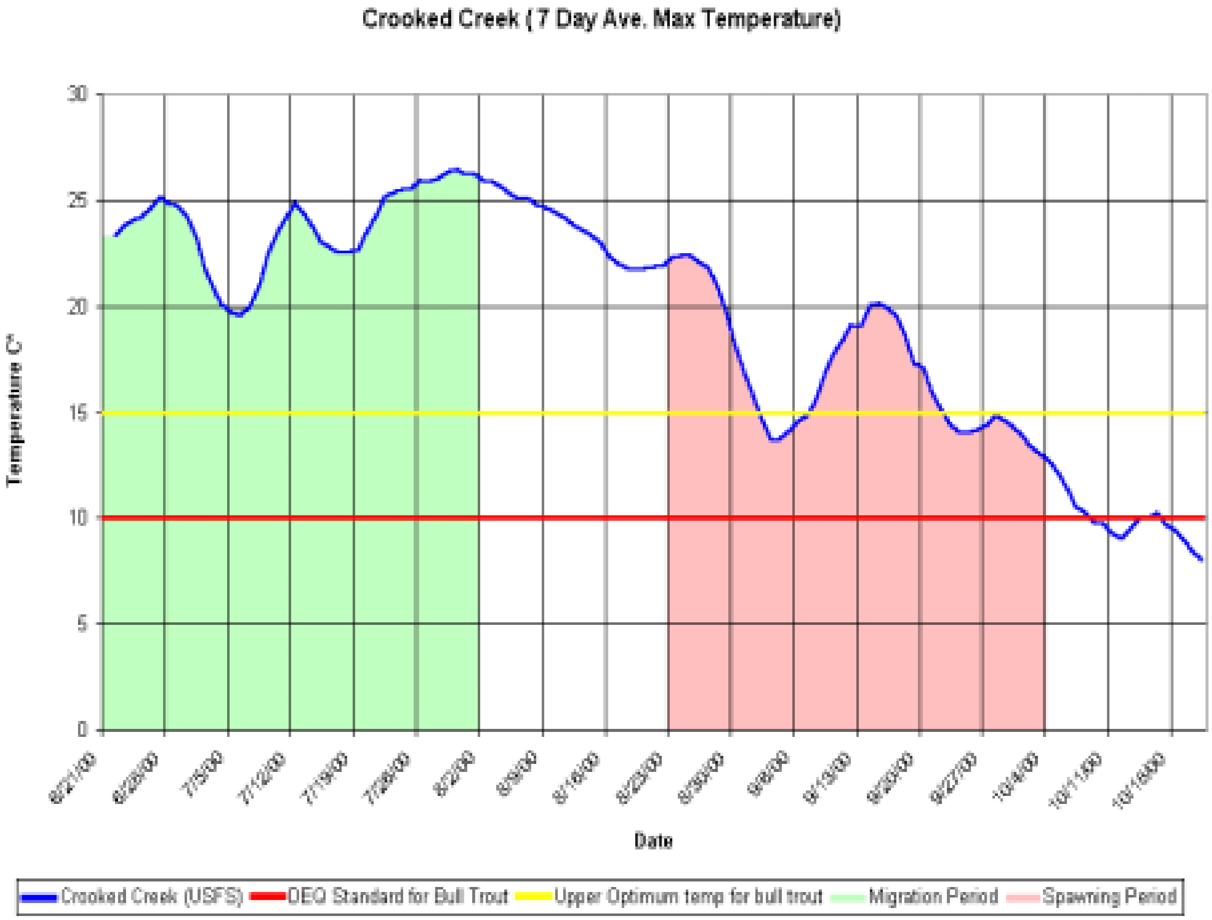


**Figure 12.** Comparison of the 7-day average maximum temperatures for Crooked Creek with DEQ standards and migration/spawning periods for bull trout in the Upper Malheur basin.

Crooked Creek is a tributary of Lake Creek entering at RK 1. There was only one probe placed in Crooked Creek (Figure 10). There are documented sightings of bull trout in Crooked Creek (Buchanan 1997). The Burns Paiute Tribe documented bull trout in Crooked Creek in 1998, but did not find them during population and habitat surveys of 2000. Crooked Creek is characterized as a low gradient stream with low flow and sections of dry channel in the upper reaches. Temperatures exceed standards established by DEQ for bull trout in late spring and summer as well as the upper optimum threshold for adult bull trout (McPhail and Murray 1979, Shepard et al. 1984, Buckman et al. 1992, Ratliff 1992, Buchanan and Gregory 1997). Acceptable water temperatures for spawning bull trout have been documented to be less than 10° C (McPhail and Murray 1979, Shepard et al. 1984, Buckman et al. 1992, Ratliff 1992, Buchanan and Gregory 1997). Temperatures in Crooked Creek exceeded those thresholds for the duration in which spawning would have been expected to occur.

***McCoy Creek:***

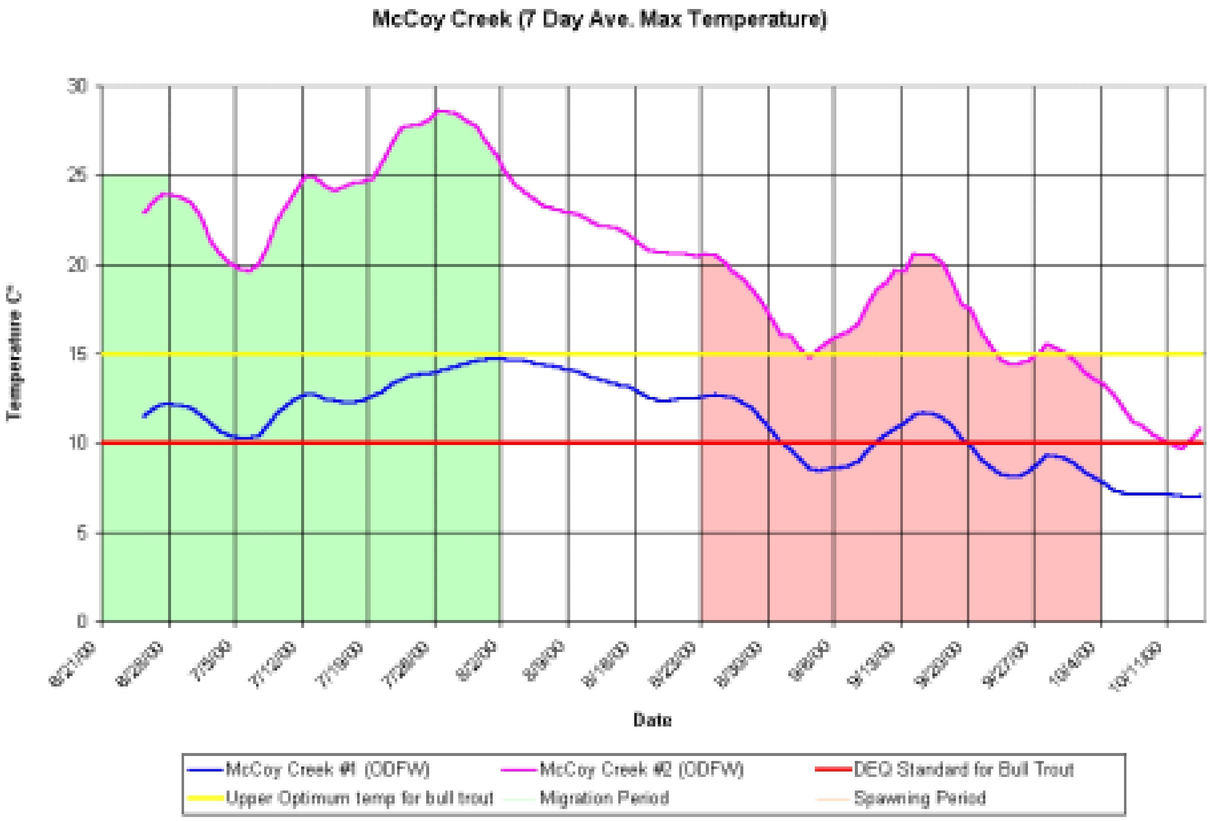


**Figure 13.** Comparison of the 7-day average maximum temperatures for McCoy Creek with DEQ standards and migration/spawning periods for bull trout in the Upper Malheur basin.

McCoy Creek is a tributary of Lake Creek entering at RK 3 (Figure 10). This creek is considered data limited by local agencies. Information has not been documented in reference to habitat, fish abundance, and distribution. There were efforts in 1993 by ODFW to document bull trout populations within the Malheur basin (Bowers 1993). Brook trout *Salvelinus fontinalis* were the only char documented utilizing McCoy Creek.

Probe # 2 temperatures exceed standards established by DEQ for bull trout in late spring and summer as well as the upper optimum threshold for adult bull trout (McPhail and Murray 1979, Shepard et al 1984, Buckman et al. 1992, Ratliff 1992, Buchanan and Gregory 1997). Probe #1 exhibited trends that were more bull trout friendly. Temperatures generally exceeded standards established by DEQ but remained lower than the upper optimum temperatures for adult bull trout. Acceptable water temperatures for spawning bull trout are to be less than $10^{o}$ C. Temperatures in McCoy Creek exceeded those thresholds but could be considered cyclic ranging from $8^{o}$ C to $12^{o}$ C in the upper reaches allowing for spawning to occur if bull trout were present.

## Discussion

Bull trout in the Upper Malheur River are considered to be at “High Risk” of extinction (Ratliff & Howell 1992). In 1998 bull trout became listed under the Federal Endangered Species Act as “threatened” in June 1998. Preliminary genetic work has been completed on bull trout in the Upper and North Fork of the Malheur River (Spruell & Allendorf, 1997), but the data analyses within the Malheur was limited by small sample sizes and may need to be further studied. The conclusion of the preliminary study was that the two populations were genetically similar but due to the construction of the two irrigation dams (Agency Valley Dam 1935 and Warm Springs Dam 1919) these populations have been isolated from each other for roughly 67 years. Given the current health of the landscape, major changes will need to be made in land and water use practices to ensure the persistence of bull trout in the Malheur system.

Temperatures in the Upper Malheur River appear to be a limiting factor for bull trout. Historic information of their distribution in the Basin is limited. The first documentation of this species in the Upper Malheur was in 1955, when bull trout were observed as far down stream as Wolf Creek during an ODFW chemical poisoning project (Hanson et al. 1990). Although there is no recent documentation to prove their presence, it is assumed that bull trout accessed the Snake and Columbia Rivers before dams blocked fish passage.

The continued efforts of cooperating agencies working with the Tribe is commendatory in the documentation of past and current trends, but the data of 2000 doesn’t present any new information. The Malheur River and tributaries are consistently too warm during migratory and spawning periods to sustain healthy reproducing population of bull trout with out future restoration.

The below table depicts the number of days temperature exceeds the standards. Graphed images of each probe can be viewed in the results section of this report.

**Table 2.** Days exceeding DEQ standards

| Temperatures are based on daily maximum temperatures. | | | | | |
|---|---|---|---|---|---|
| Data Logger | Total Temperature days recorded | **Day’s over 10º C** (DEQ standards for bull trout) | **Day’s over 12.8º C** (DEQ standards for migrating and spawning Salmonids) | **Day’s over 15º C** (Upper Optimum temperature for bull trout) | **Day’s over 17.8º C** (DEQ standards for salmonid fish rearing) |
| Malheur River #1 (BPT) | 82 | 82 | 78 | 73 | 59 |
| Malheur River #2 (BPT) | 125 | 119 | 112 | 93 | 78 |
| Malheur River #3 (USFS) | 135 | 122 | 109 | 93 | 78 |
| Malheur River #4 (BPT) | 130 | 121 | 109 | 94 | 73 |
| Malheur River #5 (BPT) | 142 | 116 | 105 | 92 | 78 |
| | | | | | |
| Big Creek #1 (USFS) | 123 | 0 | 0 | 0 | 0 |
| Big Creek #2 (USFS) | 123 | 0 | 0 | 0 | 0 |
| Big Creek #3 (ODFW) | 159 | 83 | 11 | 0 | 0 |

| | | | | | |
|---|---|---|---|---|---|
| Big Creek #4 (ODFW) | 159 | 120 | 90 | 66 | 15 |
| Big Creek #5 (BPT) | 83 | 81 | 70 | 57 | 4 |
| Big Creek #6 (BPT) | 112 | 112 | 95 | 84 | 55 |
| | | | | | |
| Meadow Fork Creek #1 (ODFW) | 147 | 64 | 0 | 0 | 0 |
| Meadow Fork Creek #2 (ODFW) | 147 | 74 | 15 | 0 | 0 |
| | | | | | |
| Lake Creek #1 (USFS) | 123 | 68 | 10 | 0 | 0 |
| Lake Creek #2 (ODFW) | 112 | 72 | 23 | 0 | 0 |
| Lake Creek #3 (ODFW) | 112 | 104 | 92 | 78 | 62 |
| Lake Creek #4 (ODFW) | 112 | 105 | 100 | 83 | 74 |
| Lake Creek #5 (BPT) | 82 | 82 | 82 | 76 | 70 |
| Lake Creek #6 (BPT) | 82 | 82 | 82 | 76 | 70 |
| | | | | | |
| McCoy Creek #1 (ODFW) | 112 | 78 | 28 | 0 | 0 |
| McCoy Creek #2 (ODFW) | 112 | 110 | 102 | 91 | 75 |
| | | | | | |
| Crooked Creek (USFS) | 122 | 110 | 104 | 87 | 78 |

The Burns Paiute Tribe administered a radio telemetry study on bull trout in the Upper Malheur in 2000 (BPT 2000). There were 20 bull trout (> 240 mm fork length) tagged and released at RK 304 between Malheur probe #1 and Malheur probe #2. Tagged bull trout ventured up the Malheur and into Big Creek. From there 12 migrated to Meadow Fork Creek, 1 migrated to Snowshoe Creek, and two stayed in Big Creek. Of the twenty radioed bull trout, five were unaccounted for (lost to predators or angling).

Based on the results of the temperature data and the telemetry data in the Upper Malheur River, Meadow Fork Creek was favored for spawning by bull trout in 2000.

## Recommendations / Future Projects

The 2000 temperature and telemetry data has raised some interesting questions such as why there is not a greater distribution of bull trout in some of these headwater tributaries. Some of these tributaries do exhibit potential for restoration. Future projects should include: Improving riparian vegetation, changes in land use practices to favor bull trout, eradication of exotic species (Brook trout), flow modification (Putting water back in stream), and aquatic habitat improvement. There needs to be an outreach to the private landowner to practice "Best

Management Techniques" for future land management if the fish species within the Malheur Basin are to persist.

## Acknowledgements

A special thanks is extended to: Jason Fenton, Burns Paiute Fish and Wildlife Department for his work putting together the GIS maps for the project and this paper, ODFW, and the USFS who worked with the Tribe to coordinate this effort. Thanks to Bonneville Power Administration who provided the funds to the Burns Paiute Tribe Fish and Wildlife Department to take the lead in this research.

## References

Bowers, W.L., P.A. Dupee, M.L. Hanson, and R.R. Perkins. 1993 bull trout population summary Malheur River basin. Oregon Department of Fish and Wildlife, Hines, Oregon. Unpublished report.

Buchanan, M. W. and S. V. Gregory, 1997. Development of water temperature standards to protect and restore habitat for bull trout and other cold water species in Oregon. Pages 119 – 126 in McKay, W.C., M.K. Brewin, and M. Monita, ediors. Friends of the bull trout conference proceeding. Bull trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary.

Buckman, R.C., W.E. Hosford, and P.A. Dupee. 1992. Malheur River bull trout investigations. Pages 45-57 *in* P.J. Howell and D.V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, OR.

Dambacher, J.M. and K.K. Jones. 1997. Stream Habitat of Juvenile Bull Trout Populations in Oregon and Benchmarks for Habitat Quality. Pages 353 – 360 in McKay, W.C., M.K. Brewin, and M. Monita, editors. Friends of the bull trout conference proceeding. Bull trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary.

Hanson,L. M., R. C. Buckman and W. E. Hosford. 1990. Malheur River Basin Fish Management Plan. Oregon Department of Fish and Wildlife, Portland.

Howell, P.J. and D.V. Buchanan, editors. 1992. Proceedings of the Gearhart Mountain bull Trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, OR.

Mc Phail, J.D. and C.B. Murray. 1979. The early life-history and ecology of Dolly Varden (Salvelinus malma) in the upper Arrow Lakes. University of British Columbia, Department of Zoology and Institute of Animal Resources, Vancouver, Canada.

Oregon Department of Fish and Wildlife. 1998. Aquatic Inventory Project: Methods for Stream

Habitat Survyes, version 8.1. Natural Production Program. Corvallis, OR.
Oregon Department of Enviornmental Quality. Final 1998. 303 (d) listings and map. Portland. Oregon.

Oregon Water Resources Department. 1983. Malheur River Basin. Salem, OR.

Perkins, R. 1998. Malheur River Bull Trout Population Status. Oregon Department of Fish & Wildlife. Special Report: Southeast Fisheries District. Ontario, OR.

Ratliff, D.E. and P.J. Howell. 1992. The status of bull trout populations in Oregon. Pages 10-17 in P.J. Howell and D.V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the AFS. Corvallis, OR.

Shepard, B., K.L. Pratt, and P. Graham. 1984. Life history of westslope cutthroat and bull trout in the upper Flathead River Basin, Montana. Montana Dept. of Fish, Wildlife, and Parks.

Spruell, P. and F.W. Allendorf. 1997. Nuclear DNA Analysis of Oregon Bull Trout. Report 97/5. University of Montana, Division of Biological Sciences, Missoula, MT 59812

## Appendices A.
## Oregon's Final 1998 Water Quality Limited Streams - 303(d) List
## Malheur River Basin Data

| Sub Basin | Name & Description | Parameter | Criteria | Season | Supporting Data or Information | Changes From 1994/96 |
|---|---|---|---|---|---|---|
| Lower Malheur | **Malheur River** Mouth to Hog Creek (Namorf) | Bacteria | Water Contact Recreation (fecal coliform-96 Std) | Summer | USBR Data (4 Sites: MAL006, MAL102, MAL103, MAL104; RM 0.5, 20, 49, 67.2): 56% (22/39); 69% (27/39); 15% (6/39); 6% (2/31) Summer values respectively exceeded fecal coliform standard (400) with a maximum of 9000 between WY 1986 - 1995. | No Change |
| Lower Malheur | **Malheur River** Mouth to Hog Creek (Namorf) | Bacteria | Water Contact Recreation (fecal coliform-96 Std) | Fall-Winter-Spring | USBR Data (4 Sites: MAL006, MAL102, MAL103, MAL104; RM 0.5, 20, 49, 67.2): 12% (6/52); 19% (10/52); 5% (3/58); 0% (0/40) FWS values respectively exceeded fecal coliform standard (400) with a maximum of 10,800 between WY 1986 - 1995. MOWC 7 sites for spring/summer of 1997 showed no exceedence of fecal coliform or e. coli bacteria standard. Need several more years of data to consider removing from 303d list. | No Change |
| Lower Malheur | **Malheur River** Mouth to Hog Creek (Namorf) | Chlorophyll a | | Summer | USBR Data (4 Sites: MAL006, MAL102, MAL103, MAL104; RM 0.5, 20, 49, 67.2): 87% (27/31); 65% (20/31); 19% (6/31); 6% (2/31) Summer values respectively exceeded chlorophyll a standard (15 ug/l) with 3 month ave exceeding each year in lower R from WY 86-95. | No Change |
| Lower Malheur | **Malheur River** Mouth to Hog Creek (Namorf) | Toxics | Water - Pesticides (DDT) | | USGS Data (Site at Malheur River near Ontario): 3 water samples with a range of 0.001 - 0.004 ug/l and an average of 0.003 ug/l exceeded DDT standard (fresh chronic criteria - 0.001 ug/l, water and fish ingestion - 0.024 ng/l) in 1990. | No Change |
| Lower Malheur | **Malheur River** Mouth to Hog Creek (Namorf) | Toxics | Water - Pesticides (Dieldrin) | | USGS Data (Site at Malheur River near Ontario): 3 water samples with a range of 0.003 - 0.010 ug/l and an average of 0.007 ug/l exceeded Dieldrin standard (fresh chronic criteria - 0.0019 ug/l, water and fish ingestion - 0.071 ng/l) in 1990. | No Change |
| Middle Snake / Payette | **Shepard Gulch** Mouth to Headwaters | Bacteria | Water Contact Recreation (fecal coliform-96 Std) | Spring/Summer | Malheur Co Data (Site 40, 07Z008, at Mosquite Road): 88% (7 of 8) Summer values exceeded fecal coliform standard (400) with a maximum of 44,000 in 1978 - 1980. | No Change |

| Sub Basin | Name & Description | Parameter | Criteria | Season | Supporting Data or Information | Changes From 1994/96 |
|---|---|---|---|---|---|---|
| Upper Malheur | **Bear Creek** Mouth to Headwaters | Temperature | Rearing 64 F (17.8 C) | Summer | USFS Data (Site at 16S,36E,33): 7 day average of daily maximums of 80 with 71 days exceeding temperature standard (64) in 1993. | No Change |
| Upper Malheur | **Big Creek** Mouth to Meadow Fork | Temperature | Oregon Bull Trout 50 F (10 C) | Summer | ODFW Data (Site at FSR 16, 16S,33.5E,14): 7 day average of daily maximums of 59 and 61 exceeded Bull Trout temperature standard (50) in 1993 and 1994 respectively. | No Change |
| Upper Malheur | **Bluebucket Creek** Mouth to Headwaters | Temperature | Rearing 64 F (17.8 C) | Summer | BLM Data (Site North of Moffit Table, 18S,34E,34sene): 7 day average of daily maximums of 79.5 with 44 days exceeding temperature standard (64) in 1995. In 1997 was 21.2 °C. | No Change |
| Upper Malheur | **Lake Creek** Mouth to Headwaters | Temperature | Oregon Bull Trout 50 F (10 C) | Summer | ODFW Data (Site at FSR 16, 16S,33.5E,14): 7 day average of daily maximums of 65 and 74 exceeded Bull Trout temperature standard (50) in 1993 and 1994 respectively. | No Change |
| Upper Malheur | **Little Malheur River** Mouth to Headwaters | Temperature | Rearing 64 F (17.8 C) | Summer | USFS Data (Site at FSR 1672, 15S,36E,25): 7 day average of daily maximums of 70 and 80 exceeded temperature standard (64) in 1993 and 1994 respectively; BLM data also available. | No Change |
| Upper Malheur | **Malheur River** North Fork Malheur R to Warm Springs Res | Bacteria | Water Contact Recreation (fecal coliform-96 Std) | Summer | Malheur Co Data (Site 5, 07F010, near Juntura): 75% (6 of 8) Summer values exceeded fecal coliform standard (400) with a maximum of 3800 in 1978 - 1980. MOWC data in 1997 shows no exceedence of Fecal Coliform or E. Coli bacteria standard, need several more years of data to consider removing from 303d list. | No Change |
| Upper Malheur | **Malheur River** Warm Springs Reservoir to Wolf Creek | Flow Modification | | | Redband Trout are a state sensitive species, water withdrawal has been identified as a concern (ODFW, 1990); IWR (68359) is often not met at USGS gage (13214000). | No Change |
| Upper Malheur | **Malheur River** Warm Springs Reservoir to Wolf Creek | Temperature | Rearing 64 F (17.8 C) | Summer | BLM Data (3 Sites: Upton Cabin, 22S,36E2nwsw; Carey Spring, 21S,36E,21swsw; Below Hwy 20, 21S,36E,5nese): 7 day average of daily maximums of 80.1; 71.5; 77.7 with 41; 14; 36 days respectively exceeding temperature standard (64) in 1995. | No Change |

| Sub Basin | Name & Description | Parameter | Criteria | Season | Supporting Data or Information | Changes From 1994/96 |
|---|---|---|---|---|---|---|
| Upper Malheur | **Malheur River** Wolf Creek to Headwaters | Temperature | Rearing 64 F (17.8 C) | Summer | USFS Data (Site at FSR 1651 (RM 183), 17S-34E-18): 7 day average of daily maximums of 77/76/71/79 with 54/82/57/78 days exceeding temperature standard (64) in 1991/92/93/94 respectively. Two BLM sites in 1997 were 24.1 and 24.6 °C. | No Change |
| Upper Malheur | **Malheur River, North Fork** Mouth to Beulah Reservoir | Bacteria | Water Contact Recreation (fecal coliform-96 Std) | Spring/Summer | Malheur Co Data (Site 6, 07F003, near mouth): 66% (8 of 12) Summer values exceeded fecal coliform standard (400) with a maximum of 8000 in 1978 - 1980. MOWC data in 1997 shows no exceedence of Fecal Coliform or E. Coli bacteria standard, need several more years of data to consider removing from 303d list. | No Change |
| Upper Malheur | **Pine Creek** Mouth to Alkali Creek | Temperature | Rearing 64 F (17.8 C) | | USFS Data (Site at FSR 120): 7 day average of daily maximums of 75 and 77 with 88 and 100 days exceeding temperature standard (64) in 1993 and 1994 respectively. | No Change |
| Upper Malheur | **Summit Creek** Mouth to Headwaters | Temperature | Rearing 64 F (17.8 C) | Summer | USFS Data (Site at FSR 1651; RM 2.75): 7 day average of daily maximums of 80, 76, and 79 with 77, 84, and 80 days exceeding temperature standard (64) in 1992, 1993, and 1994 respectively. | No Change |
| Upper Malheur | **Wolf Creek** Mouth to Headwaters | Temperature | Rearing 64 F (17.8 C) | Summer | USFS Data (Site at FSR 15, 18S-33E-18): 7 day average of daily maximums of 75 with 69 days exceeding temperature standard (64) in 1994. | No Change |
| Upper Malheur | **East Fork** Mouth to Headwaters | Temperature | Rearing 64 F (17.8 C) | Summer | USFS Data (Site at mouth, 18S-33E-12): 7 day average of daily maximums of 69 and 78 with 34 and 82 days exceeding temperature standard (64) in 1992 and 1994 respectively. | No Change |

# MICROSATELLITE ANALYSIS OF REDBAND RAINBOW FROM THE UPPER MALHEUR BASIN

Author: Paul Spruell and Aaron Maxwell, Wild Trout and Salmon Genetics Laboratory, Division of Biological Sciences, University of Montana Missoula, MT

## Summary

We used six microsatellite loci to estimate the level of genetic differentiation among 14 populations of rainbow trout (*Oncorhynchus mykiss*) from sites throughout the Northwest United States. The expected heterozygosity in the Malheur region ranged from 0.649 to 0.705, with the observed heterozygosity ranging from 0.571 to 0.694. These values are within the range of heterozygosities observed in steelhead populations from the Hood River, though slightly higher than those observed in Kootenai redband populations from Montana. The level of differentiation among the five Malheur sample sites was quite low ($F_{st}$= 0.004). $F_{st}$ is a measure of population differentiation in which a $F_{st}$ of 0 indicates no differentiation, $F_{st}$ of 1 indicates maximal differentiation. We also compared these samples to rainbow trout populations from 9 other locations in the Northwest. The differentiation level across these 14 sample sites was $F_{st}$=0.165.

## Methods

Samples were collected by Burns Paiute personnel (Figure 2) and were delivered to the Wild Trout and Salmon Genetics Lab in 95% ethanol. DNA was extracted using the Puregene kit (Gentra) following the manufacturer's instructions. We amplified six microsatellite loci using previously described methods (Knudsen and Spruell 1999). The resulting data were analyzed as described in Neraas and Spruell (In Press).

## Results

*Upper Malhuer Basin*

All loci analyzed were polymorphic in the samples from the Upper Malheur Basin. The number of alleles, expected heterozygosities and observed heterozygosities are provided in Table 1. After correcting for multiple tests (Rice 1989), we observed no significant deviations (P>0.05) from Hardy-Weinberg expectations at any of the loci in any population.

The levels of heterozygosity observed *within* Malheur Basin samples are consistent with heterozygosity estimates for steelhead from the Hood River in Oregon (Table 1). Interestingly, these values are substantially higher than the heterozygosity estimates for other interior "redband" populations from northwest Montana (Table 1).

There was relatively little genetic differentiation among the five sample sites from the Upper Malhuer Basin ($F_{st}$=0.0039). This lack of divergence is also reflected in few loci exhibiting significant differences in allele frequencies. Bear Creek and Crane Creek/Little Crane Creek were the only two populations in which genotypic frequencies were significantly different at three of six loci. The remaining nine comparisons differed at two or fewer loci. Highly differentiated populations are often different at most loci analyzed.

*Comparison with other Samples*

Samples from the Upper Malhuer Basin were compared to rainbow trout from other Northwest sites (Fig. 1). These samples were analyzed as part of other ongoing research at the University of Montana. Samples included steelhead from the Hood River in Oregon and interior rainbow trout from the upper Kootenai Basin, Montana (upper Yaak, Northfork Yaak). There are substantial differences between samples from the Kootenai Basin and all other samples. Although the samples from the Malheur Basin do form a discrete cluster on the dendrogram, there was surprisingly little differentiation between Malheur Basin samples and steelhead from the Hood River (Fig. 1).

## Discussion

There was very little differentiation among the rainbow populations sampled from Upper Malheur Basin ($F_{st}$=0.004). This value is low when compared to microsatellite-based studies of most other inland salmonids. For example, Knudsen has estimated $F_{st}$ to be 0.427 for six populations of native redband trout (*Oncorhynchus mykiss*) from the upper Kootenai Basin (unpublished data). Similarly**,** Neraas and Spruell (*In Press*) report an $F_{st}$ of 0.137 for bull trout (*Salvelinus confluentus*) from the lower Clark Fork River and Lake Pend Oreille. Samples from the upper Malheur and upper Kootenai regions span similar geographic distances. However, the genetic similarity among samples from the Malheur is far less than that observed in the upper Kootenai.

## Acknowledgements

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†Paul Spruell

and

Aaron Maxwell

Wild Trout and Salmon Genetics Laboratory
Division of Biological Sciences
University of Montana
Missoula, MT 59812

†author to whom correspondence should be addressed
phone (406) 243-6749
fax (406) 243-4184
E-mail spruell@selway.umt.edu

## References

Knudsen, K. L. and P. Spruell (1999) Genetic analysis of westslope cutthroat trout in tributaries of Couer d'Alene Lake. Wild Trout and Salmon Genetics Lab Report WTSGL99-106 to the Coeur d'Alene Tribe.

Neraas, L. P. and P. Spruell (In Press) Fragmentation of riverine systems: the genetic effects of dams on bull trout (*Salvelinus confluentus*) in the Clark Fork River system. Mol. Ecol.

Rice, W. R. (1989) Analyzing tables of statistical tests. Evolution 43: 223-225.

**Table 1**. Sample sizes, average number of alleles per locus, expected heterozygosities ($H_e$) and observed heterozygosities ($H_o$) estimated using six microsatellite loci.

| Sample | Sample size | Average number of alleles per locus | $H_e$ | $H_o$ |
|---|---|---|---|---|
| Hood/Summer 93 | 30 | 6.20 | 0.684 | 0.660 |
| Hood/Summer 94 | 29 | 7.60 | 0.680 | 0.630 |
| Hood/Winter 93 | 30 | 8.00 | 0.700 | 0.683 |
| Hood/ Winter 94 | 30 | 7.40 | 0.685 | 0.698 |
| Hatchery Stock 24 | 30 | 6.20 | 0.644 | 0.680 |
| Hatchery Stock 53 | 30 | 4.00 | 0.497 | 0.565 |
| Little Malheur | 34 | 7.60 | 0.675 | 0.630 |
| Upper North Fork | 33 | 8.00 | 0.649 | 0.580 |
| Beulah | 35 | 8.60 | 0.705 | 0.694 |
| Bear Cr. | 34 | 7.60 | 0.673 | 0.660 |
| Crane/Little Crane | 30 | 7.60 | 0.649 | 0.571 |
| Upper Yaak | 30 | 2.80 | 0.366 | 0.391 |
| North Fork Yaak above | 31 | 1.60 | 0.219 | 0.234 |
| North Fork Yaak below | 28 | 3.80 | 0.463 | 0.436 |

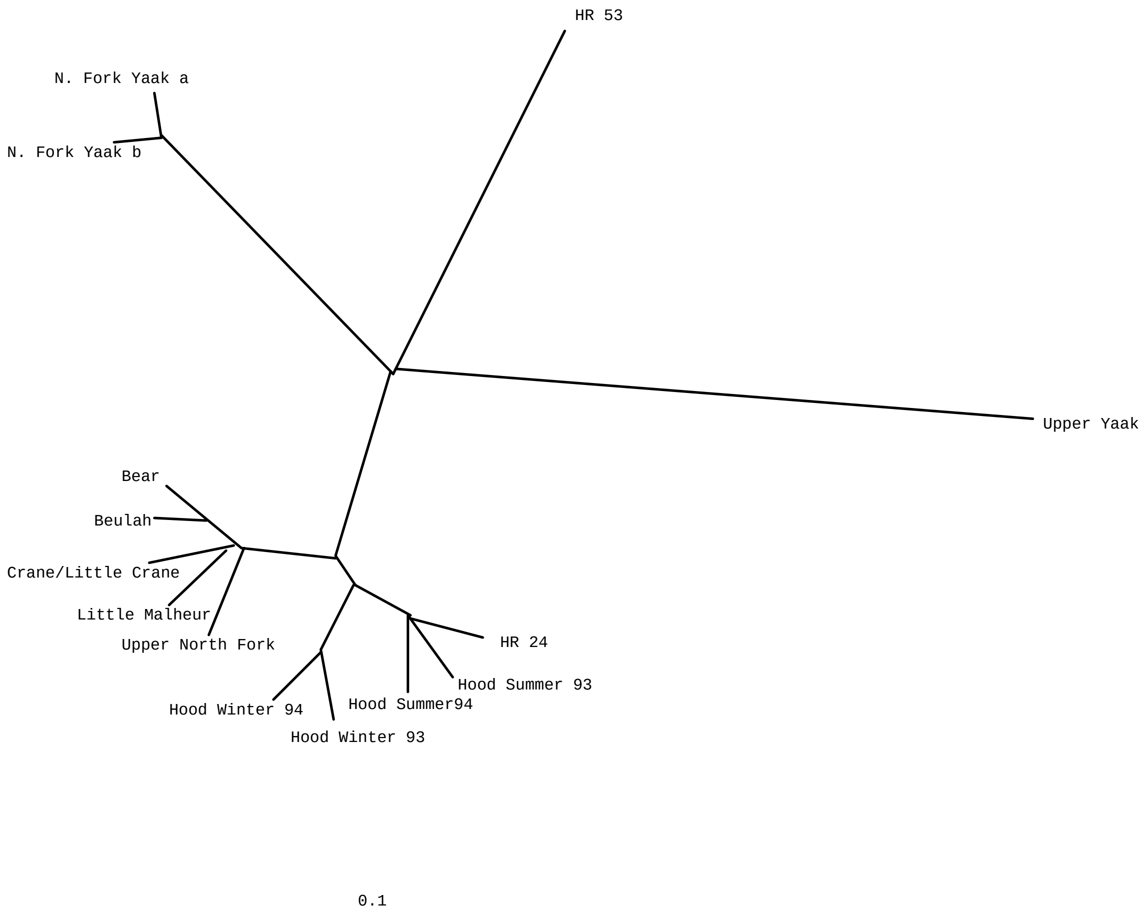


**Figure 1**: UPMGA dendrogram of sample locations based on Cavalli-Sforza and Edwards Chord Distance. The linear distance between populations corresponds to genetic similarity.

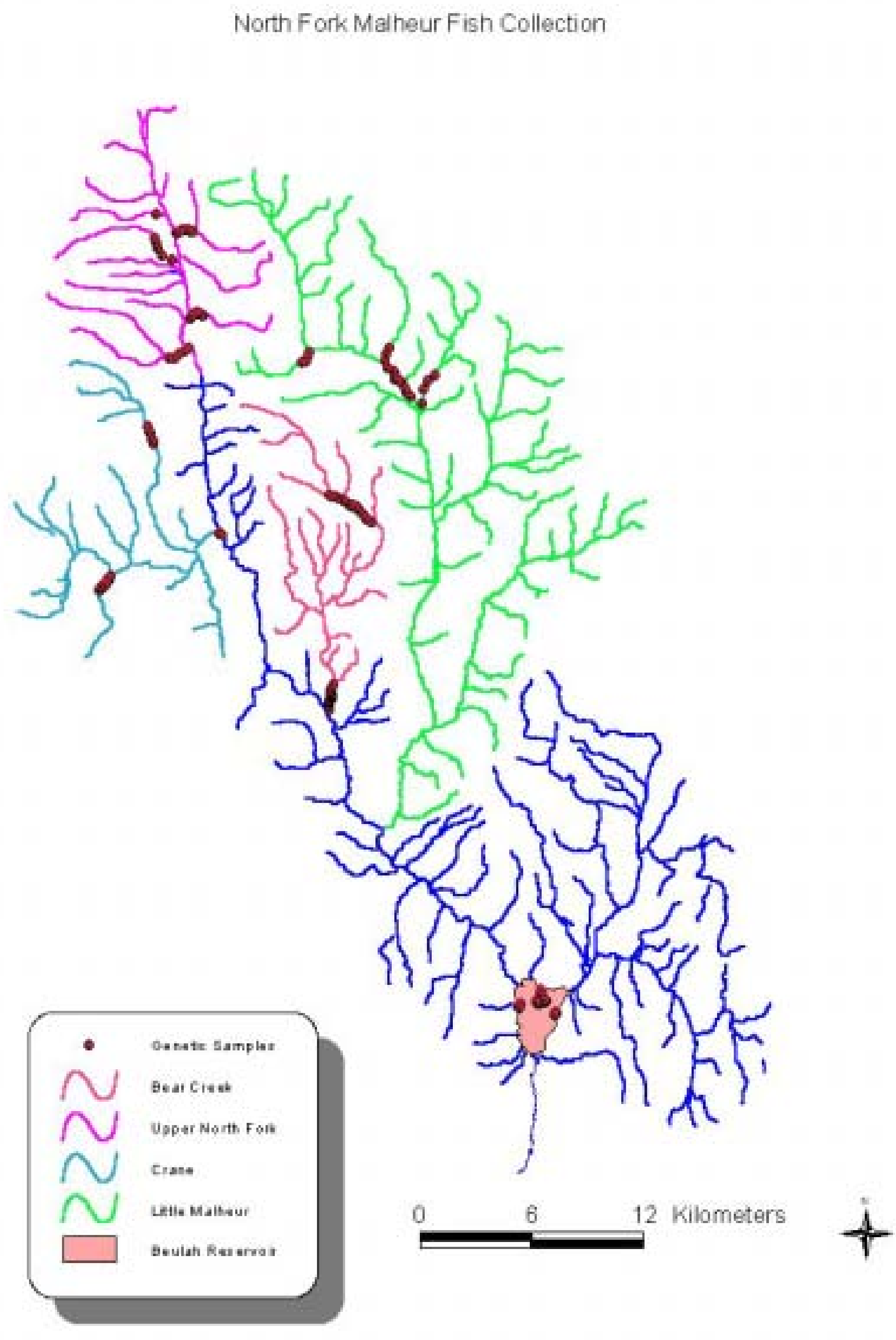


Figure 2. Redband genetic collection map of the North Fork Malheur, map produced by BPT.

# Salmonid Population Estimate for the Upper Bosonberg Creek

Author: Steve Namitz, Burns Paiute Fish and Wildlife Department, Burns, Oregon

## Introduction

Bosonberg Creek is a tributary of the Upper Malheur River entering in at River Kilometer (RK) 304. Bosonberg Creek is approximately 13 kilometers long and has a hydrologic drainage area of roughly 36.6 square kilometers. Bosonberg Creek was identified by Oregon Department of Fish and Wildlife (ODFW) as a data gap for fish species in the Upper Malheur River system.

**Project #:** 199701900

**Objective 2**. Continue monitoring population trends (index) and age class structure in native salmonids within the Malheur basin.

## Methods

*2000 Electrofishing Protocol*

The Burns Paiute Tribe Fish & Wildlife Department (BPT) administered an electrofishing effort in Bosonberg Creek from 01August 2000 to 6 September 2000 using ODFW protocol (Dambacher, 1997). The electrofishing effort was administered to determine fish population estimates within Bosonberg Creek. Efforts were made from the United States Forest Service (USFS) boundary to what is considered to be the upper limits for fish (Personal contact, District ODFW Biologist). Random shocking was conducted above the end of the survey but no fish were found.

The BPT conducted a 2/4 pass 50% reduction population survey on Bosonberg Creek (Figure 1). Sites were 50 meters in length (164 feet). Block nets were anchored into the substrate with tent pegs and rocks at the upper and lower boundary to prevent fish escapement. Survey unit #1 began at the USFS boundary (Figure 2). Sites were separated by 265-foot unshocked section of stream. One pass consisted of shocking from the lower block net up to the upper block net and back down. The second pass must have a 50% reduction in the collection of age 1+ (fork length≥70 mm) *Oncorhynchus mykiss* (redband trout) and *Salvelinus fontinalis* (brook trout) for the site to be complete. If this was not met, 2 more passes were required using the same methodology. The last site of the population survey was determined when no salmonids were collected on the first pass.

The upper limits of brook and redband trout were determined by continuing upstream, shocking 100% of the wetted channel until the stream became dry or intermittent.

*Fish collection*

Fish collection was accomplished with the use of a Smith & Root electrofisher. The protocol for shocking was to start at the down stream end of the block nets and shock moving upstream then back again. Shocking was accomplished in groups of three, one person operating the shocker, and two netters following behind. The electrofisher was tested for effectiveness in a sample area not included in the population survey. If fish were not observed reacting to the set electrical current, instruments on the shocker were adjusted to increase the impact. After the shocker was adjusted to the appropriate settings then the survey was initiated.

Once the first pass was complete, fish were counted and sorted by species. Fish lengths and weights were measured and recorded. This procedure was repeated for all passes. The percentage of fish captured on the second pass was calculated and compared to fish captured on the first pass to determine if the process needed to be repeated again to reach the 50% reduction for salmonids. If bull trout were observed the sample site was concluded and surveyors proceeded to the next site.

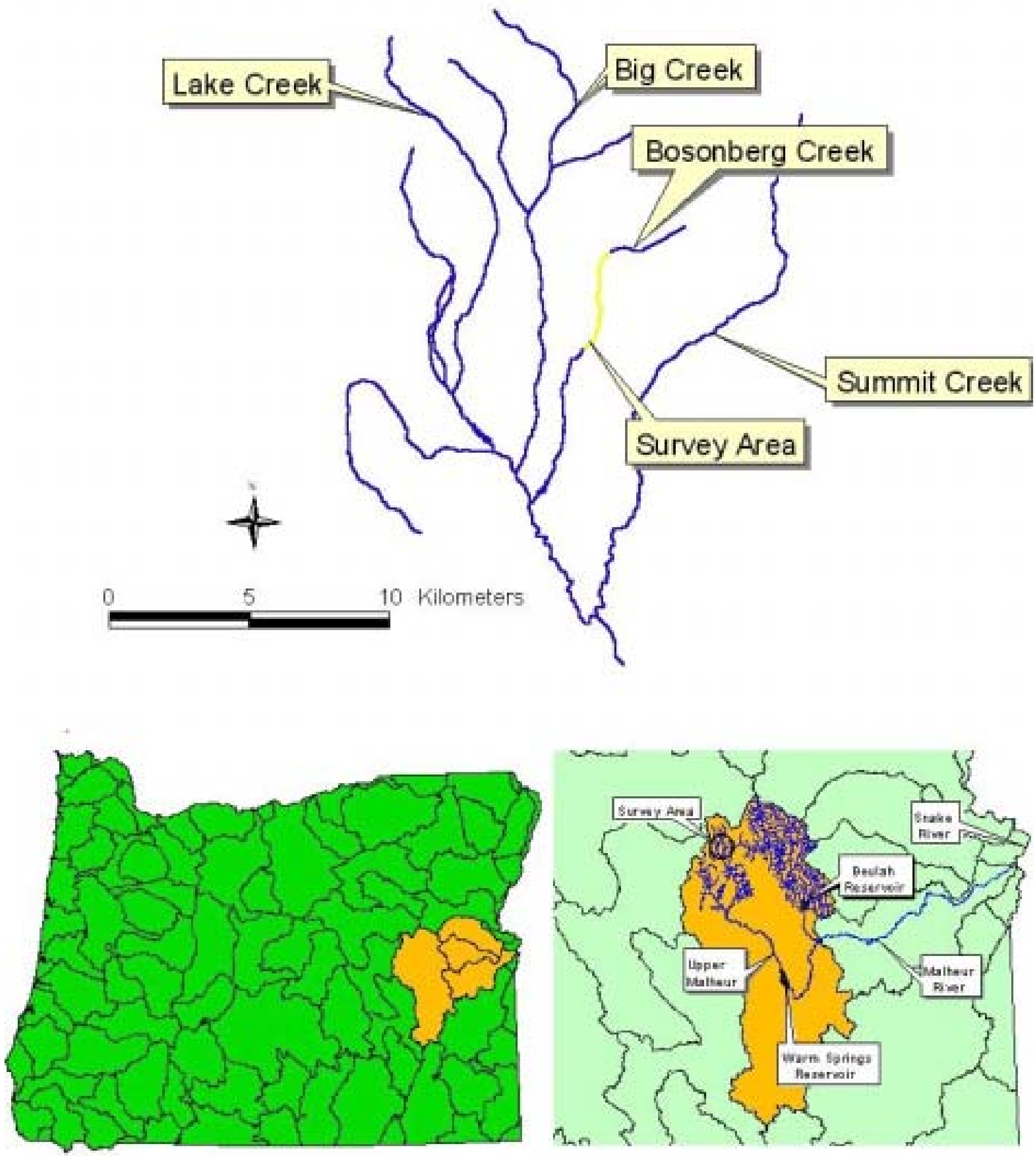


**Figure 1.** Bosonberg Creek Location Map

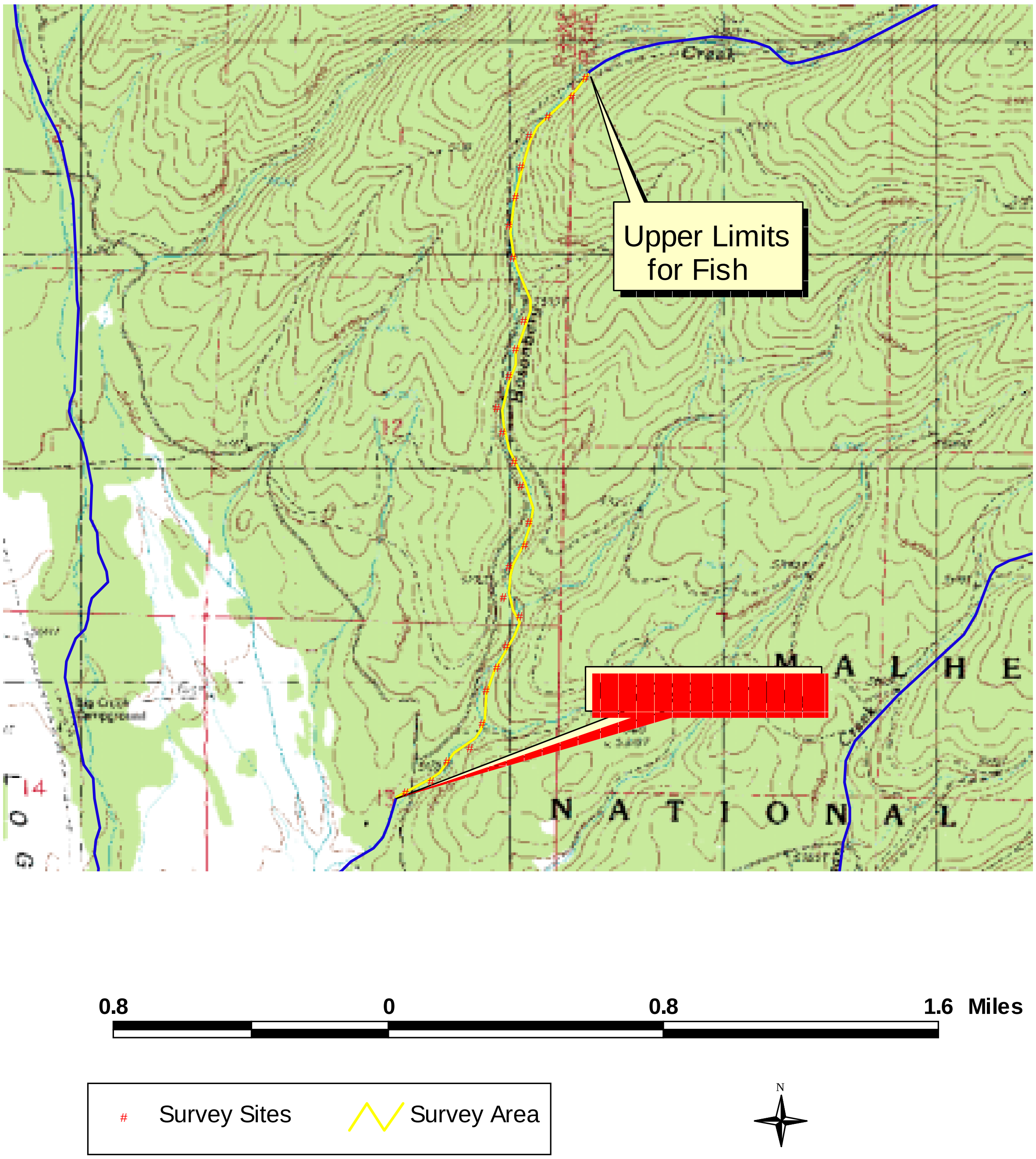


**Figure 2.** Salmonid Population Estimation and distribution survey for Bosonberg Creek (Malheur River, Oregon) in 2000

# Results

<u>Redband trout (*Oncorhynchus mykiss*)</u>

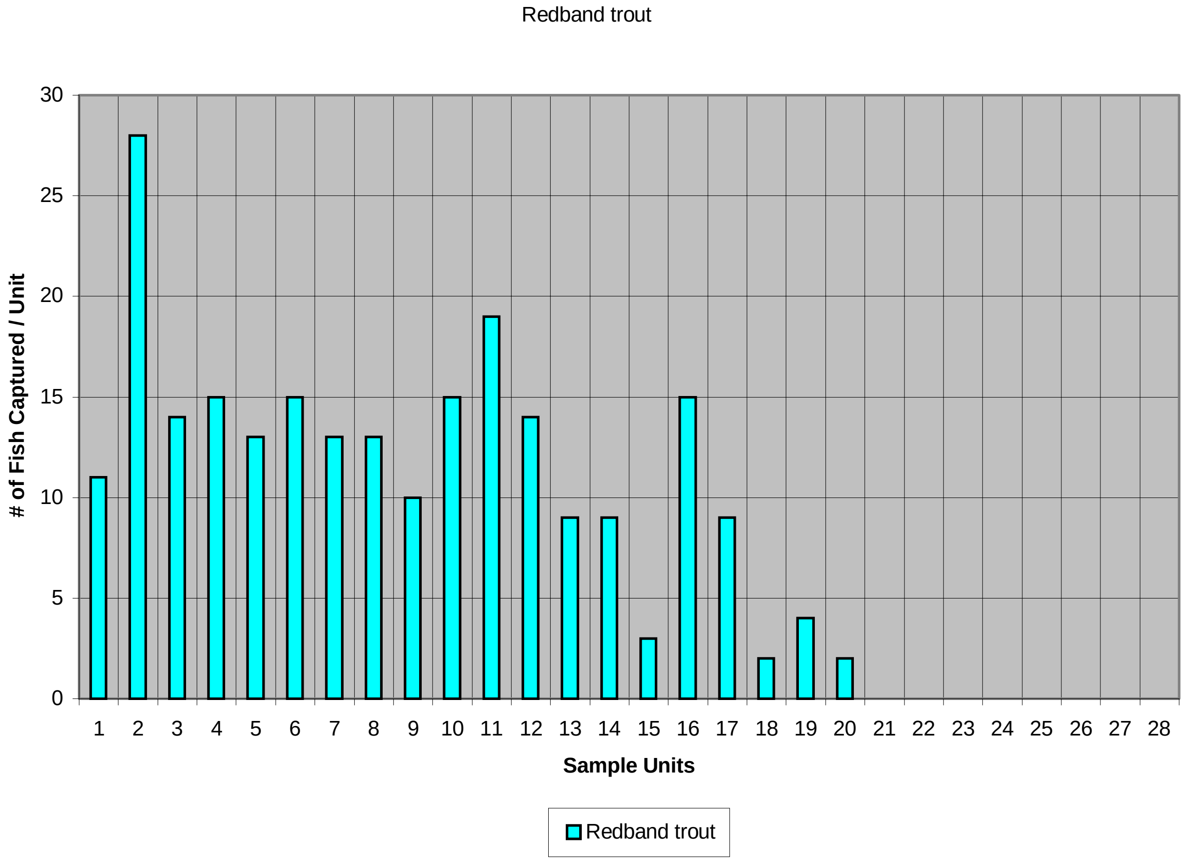


**Figure 3.** Number of redband trout captured per sample unit 2000, Bosonberg Creek.

Of the 28 units sampled, redband trout were only observed in the first 20. A 50% reduction was achieved at every sample unit. There were 233 redband trout sampled with the average probability of capture being 88% and a probability of non-capture of 12%. Of the total surveyed area, 39.5% was sampled. Average sample units were roughly 90 m$^2$. The estimated population of redband trout for the upper 3,572 meters of Bosonberg Creek was 614 fish +/- 117 fish with a 95% confidence level (Table 1). Redband statistics tables can be viewed in Appendix A.

**Table 1.** Population estimate results table for redband trout

| Results Table | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Species | | | | | | | | |
| Bosonberg Creek | | Redband 1+ | | | | | | | | |
| | | | | | | Fish per square meter | | Fish per lineal meter | | |
| | Habitat | Population | +/- | CL % of | | Habitat | Reach | | Habitat | Reach |
| | Type | Estimate | 95% c.l. | Estimate | | Type | Average | | Type | Average |
| All reaches | Mixed | 614 | 117 | 19% | | 0.0946 | na | | 0.172 | na |
| | Total | 614 | 117 | 19% | | 0.0946 | na | | 0.172 | na |

Brook Trout (*Salvelinus fontinalis*)

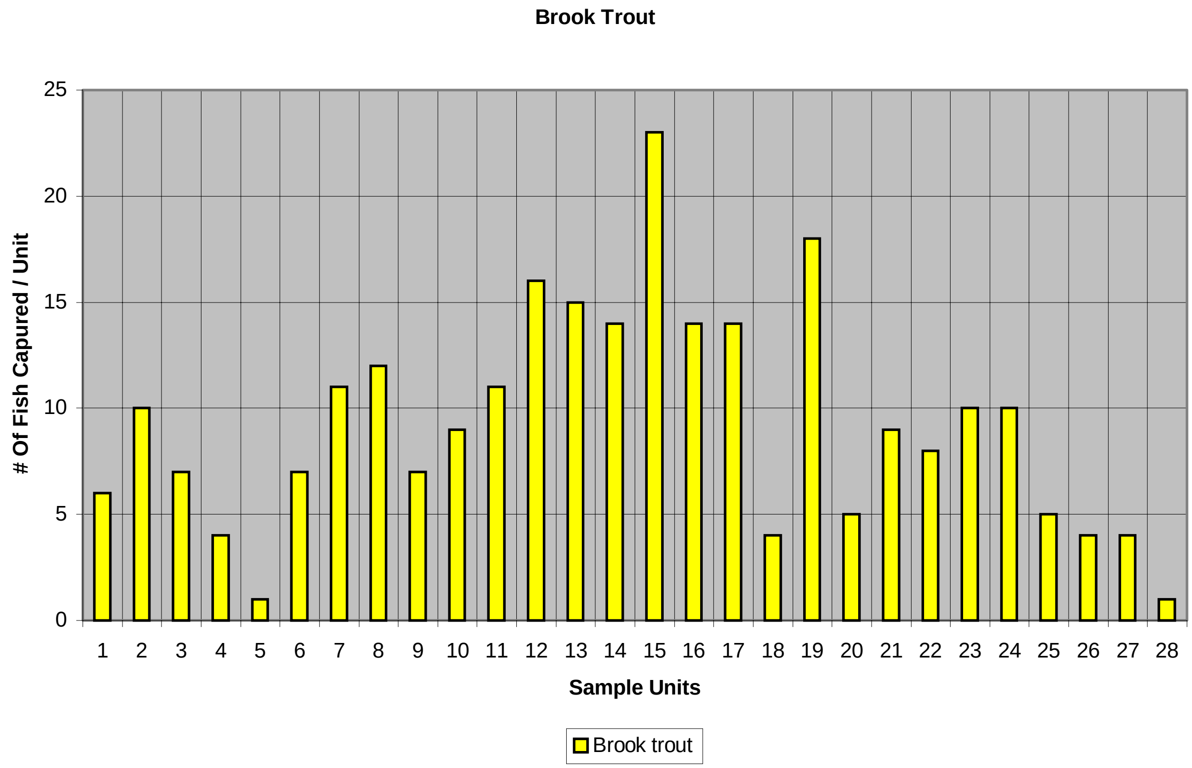


**Figure 4.** Number of brook trout captured per sample unit 2000, Bosonberg Creek.

Brook trout were observed in all 28 of the sampled units. A 50% reduction was achieved at all surveyed areas. There were 259 brook trout sampled with the average probability of capture being 78% and a probability of non-capture of 22 %. Of the total surveyed area 39.5% was sampled. Average sample units were roughly 90 $m^2$. The estimated population of brook trout for the upper 3,572 meters of Bosonberg Creek was 588 fish +/- 173 fish with a 95% confidence level (Table 2). Brook trout statistics tables can be viewed in Appendix B.

**Table2**. Population estimate results table for brook trout

| Results Table | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| Bosonberg Creek | | Brook 1+ | | | | | | | |
| | | | | | | | | | |
| | | | | | | Fish per square meter | | Fish per lineal meter | |
| | Habitat | Population | +/- | CL % of | | Habitat | Reach | Habitat | Reach |
| | Type | Estimate | 95% c.l. | Estimate | | Type | Average | Type | Average |
| All Reaches | Mixed | 588 | 173 | 29% | | 0.0905 | na | 0.165 | na |
| | Total | 588 | 173 | 29% | | 0.0905 | na | 0.165 | na |

Sculpin (*Cottus ssp.)*

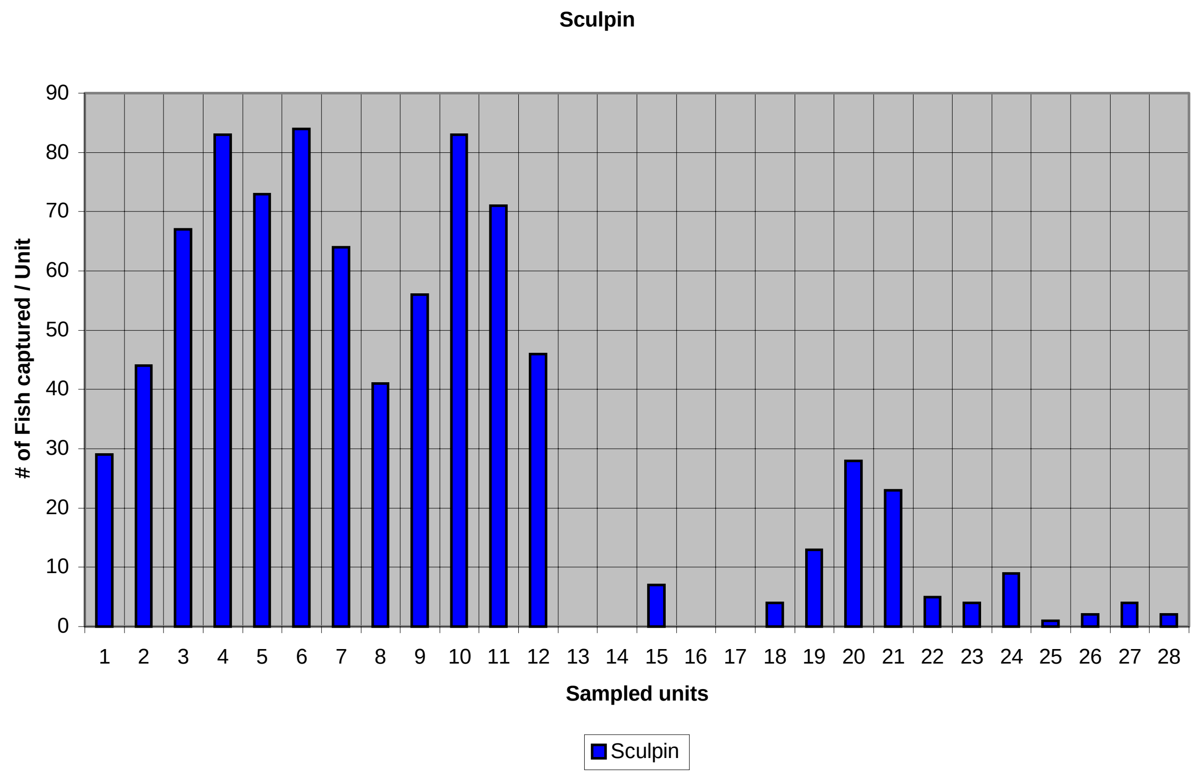


**Figure 5.** Number of sculpin captured per sample unit 2000, Bosonberg Creek.

Sculpin were observed in all but four of the sampled units. Conducting sculpin population estimates using electrofishing methods is controversial due to how sculpin react when being sampled. Sculpin are bottom dwellers and tend to avoid a taxis response to electrofishing. Sculpin data was collected but should be viewed as presence/absence estimates. Sculpin statistics tables can be viewed in Appendix C.

**Bull trout (*Salvenlinus confluentus*)**

No bull trout were observed within the 28 sampled units of Bosonberg Creek in 2000. However in 1993 Bowers documented bull trout in Bosonberg Creek as part of that years creel survey (Bowers 1993).

**Upper limits of fish species**

The upper limits of fish documented during the 2000 survey can be viewed in figure 2.

## Discussion

Salmonids were the focus of this population estimate effort. Redband and brook trout were the salmonids sampled in the upper Bosonberg Creek (Figure 3). There were a total of 28 sample locations in a 3,572 meter (11,907 feet) section. The mean habitat width for the upper portion of Bosonberg Creek was 1.8 meters (6 feet) making the sampled area roughly 6,494 $m^2$ (69,940 $ft^2$).

This is not a population estimate for all of Bosonberg Creek; rather it includes the upper portion of the watershed from the USFS boundary to the headwaters (See Figure 2 for survey area). The reason for this is the lower portion of the watershed is privately owned and access was not obtainable.

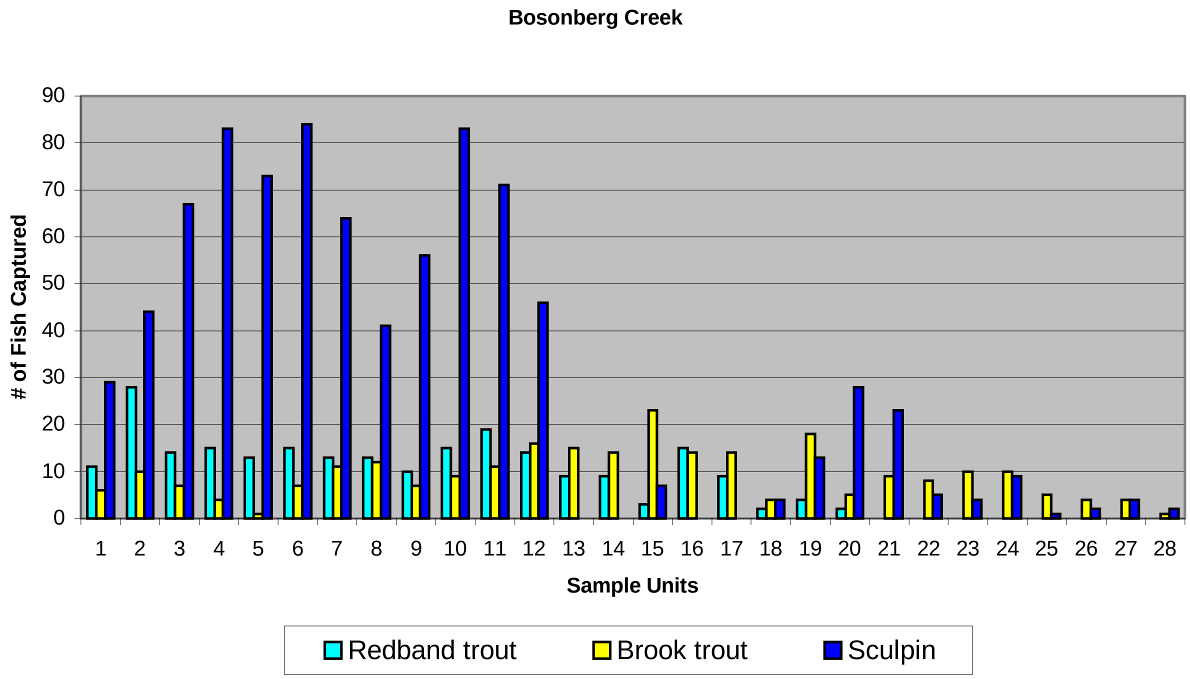


**Figure 6.** Number of fish captured per sample unit 2000, Bosonberg Creek.

From the population estimate we can conclude that redband trout and brook trout are coinciding in most of the same habitat with brook trout dominating the headwaters. The estimated populations for both species are statistically similar to each other for total number of fish present in the upper reaches of Bosonberg Creek (redband trout 614 fish +/- 117 with a 95%CL compared to brook trout 588 fish +/- 173 fish also with a 95% CL).

## Recommendations / Future Projects

The 2000 population estimates for Bosonberg Creek have raised some interesting questions such as why there are no bull trout currently present when they were found historically in the drainage (Bowers, 1993). Bull trout are also currently found in neighboring tributaries and in the main stem of the Upper Malheur River. Bosonberg Creek exhibits potential for future restoration. Potential future projects for Bosonberg Creek may include; Habitat restoration projects, exotic species eradication projects, changes in land use practices by federal agencies to favor bull trout needs. There needs to be an outreach to the private landowners to practice “Best Management

Techniques" for future land management if the salmonid species within Bosonberg Creek and the Upper Malheur Basin are to persist.

## Acknowledgements

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## References

Bowers, W.L., P.A. Dupee, M.L. Hanson, and R.R. Perkins. 1993 bull trout population summary Malheur River basin. Oregon Department of Fish and Wildlife, Hines, Oregon. Unpublished report.

Bowers, W. Personal communication with employee of Oregon Department of Fish and Wildlife, Burns, Oregon.

Buchanan, M. W. and S. V. Gregory, 1997. Development of water temperature standards to protect and restore habitat for bull trout and other cold water species in Oregon. Pages 119 – 126 in McKay, W.C., M.K. Brewin, and M. Monita, editors. Friends of the bull trout conference procedding. Bull trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary.

Buckman, R.C., W.E. Hosford, and P.A. Dupee. 1992. Malheur River bull trout investigations. Pages 45-57 *in* P.J. Howell and D.V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corallis.

Dambacher, J.M. 1997. Electrofishing Population Estimation Spreadsheet. Version 2.0

Dambacher, J.M. and K.K. Jones. 1997. Stream Habitat of Juvenile Bull Trout Populations in Oregon and Benchmarks for Habitat Quality. Pages 353 – 360 in McKay, W.C., M.K. Brewin, and M. Monita, ediors. Friends of the bull trout conference proceding. Bull trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary.

Hanson,L. M., R. C. Buckman and W. E. Hosford. 1990. Malheur River Basin Fish Management Plan. Oregon Department of Fishand Wildlife, Portland.

Howell, P.J. and D.V. Buchanan, editors. 1992. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon

Oregon Department of Fish and Wildlife. 1998. Aquatic Inventory Project: Methods for Stream Habitat Survyes, version 8.1. Natural Production Program. Corvallis, OR.

Perkins, R. 1998. Malheur River Bull Trout Population Status. Oregon Department of Fish and Wildlife. Special Report: Southeast Fisheries District. Ontario, Oregon

Ratliff, D.E. and P.J. Howell. 1992. The status of bull trout populations in Oregon. Pages 10-17 in P.J. Howell and D.V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society. Corvallis, OR.

# Appendices A.
## Redband Trout Statistical Tables

**Table 1.** Reach and Total Habitat Data Input Table

| Reach and Total Habitat Data Input Table | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Total habitat | | |
| | | Sample strata | | Number | Area | Length |
| | | Reach | Habitat | Of units | $m^2$ | m |
| | | | | | | |
| Stream: | Bosonberg | All reaches | Mixed | 70.8 | 6493.8 | 3572 |
| | | | | | | |
| Species/age: | Redband 1+ | | | | | |
| | | | | | | |
| Sample dates ("mm/dd/yy): | | | | | | |
| Starting | 80100 | | | | | |
| Ending | | | | | | |

**Table 2.** Electro fishing Data Tables

| Electrofishing Data Tables | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Bosonberg Creek | | | | Redband 1+ | | | | | |
| | | | | | | | | | | | | |
| | | ($m^2$) | (m) | | | | | | | | $(yi-rxi)^2$ | |
| Unit No. | Unit Type | Area | Length | Pass 1 | Pass 2 | yi | p | q | V(yi) | $(yi-y)^2$ | $m^2$ | m |
| 1 | Mixed | 107 | 50.0 | 11 | 0 | 11.0 | 1.00 | 0.00 | 0.0 | 5 | 1 | 6 |
| 2 | Mixed | 113 | 52.0 | 26 | 2 | 28.2 | 0.92 | 0.08 | 0.2 | 380 | 307 | 370 |
| 3 | Mixed | | 50.0 | 11 | 3 | 15.1 | 0.73 | 0.27 | 3.7 | 42 | 22 | 43 |
| 4 | Mixed | 158 | 50.0 | 13 | 2 | 15.4 | 0.85 | 0.15 | 0.7 | 45 | 0 | 46 |
| 5 | Mixed | 148 | 50.0 | 10 | 3 | 14.3 | 0.70 | 0.30 | 4.9 | 32 | 0 | 32 |
| 6 | Mixed | 105 | 50.0 | 14 | 1 | 15.1 | 0.93 | 0.07 | 0.1 | 41 | 27 | 42 |
| 7 | | 122 | 50.0 | 11 | 2 | 13.4 | 0.82 | 0.18 | 1.0 | 23 | 4 | 24 |
| 8 | Mixed | 105 | 55.0 | 13 | 0 | 13.0 | 1.00 | 0.00 | 0.0 | 19 | 10 | 13 |
| 9 | Mixed | 133 | 50.0 | 7 | 3 | 12.3 | 0.57 | 0.43 | 17.2 | 13 | 0 | 13 |
| 10 | Mixed | 94 | 55.0 | 13 | 2 | 15.4 | 0.85 | 0.15 | 0.7 | 45 | 43 | 35 |
| 11 | Mixed | 115 | 50.0 | 17 | 2 | 19.3 | 0.88 | 0.12 | 0.4 | 112 | 71 | 114 |
| 12 | Mixed | 110 | 50.0 | 14 | 0 | 14.0 | 1.00 | 0.00 | 0.0 | 28 | 13 | 29 |
| 13 | Mixed | 110 | 50.0 | 6 | | 12.0 | 0.50 | 0.50 | 36.0 | 11 | 3 | 12 |
| 14 | | 90 | | 9 | 0 | 9.0 | 1.00 | 0.00 | 0.0 | 0 | 0 | 0 |
| 15 | Mixed | 88 | 50.0 | | 0 | 3.0 | 1.00 | 0.00 | 0.0 | 32 | 28 | 31 |
| 16 | Mixed | 105 | 50.0 | 14 | 1 | 15.1 | 0.93 | 0.07 | 0.1 | 41 | 27 | 42 |
| 17 | Mixed | 88 | 50.0 | 8 | 1 | 9.1 | 0.88 | 0.13 | 0.2 | 0 | 1 | 0 |
| 18 | Mixed | 60 | 50.0 | 2 | 0 | 2.0 | 1.00 | 0.00 | 0.0 | 44 | 13 | 43 |
| 19 | Mixed | 100 | 50.0 | 4 | 0 | 4.0 | 1.00 | 0.00 | 0.0 | 22 | 30 | 21 |
| 20 | Mixed | 51 | 50.0 | 2 | 0 | 2.0 | 1.00 | 0.00 | 0.0 | 44 | 8 | 43 |
| 21 | Mixed | 52 | 50 | 0 | 0 | 0 | 1 | 0.00 | 0.0 | 75 | 24 | 74 |
| 22 | Mixed | 60 | 50 | | 0 | 0 | 1 | 0.00 | 0.0 | 75 | 32 | 74 |
| 23 | Mixed | 45 | 50 | 0 | 0 | 0 | 1 | 0.00 | 0.0 | 75 | 18 | 74 |
| 24 | Mixed | 55 | 50 | 0 | 0 | 0 | 1 | 0.00 | 0.0 | 75 | 27 | 74 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | Mixed | 65 | 50 | 0 | 0 | 0 | 1 | 0.00 | 0.0 | 75 | 38 | 74 |
| 26 | Mixed | 55 | | 0 | 0 | 0 | 1 | 0.00 | 0.0 | 75 | 27 | 74 |
| 27 | Mixed | 50 | 50 | 0 | 0 | 0 | 1 | 0.00 | 0.0 | 75 | 22 | 74 |
| 28 | Mixed | 75 | 50 | 0 | 0 | 0 | 1 | 0.00 | 0.0 | 75 | 50 | 74 |

**Table 3.** Capture Statistics Table

| Capture Statistics Table | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| Bosonberg Creek | | Redband 1+ | | | | | | | | | | | |
| | | | | | | | | | | Regular capture statistics of p | | | |
| Reach | Habitat | Pooled Capture Statistics | | | | | | | | | | +/-95% | CL % |
| Strata | Strata | p' | q' | V(p') | Ti' | xi' | V(xi') | n | | avg | std dev | CL | of p |
| All reaches | Mixed | 0.88 | 0.12 | 0.000648 | 233 | 236 | 12 | 28 | | 0.91 | 0.13 | 0.05 | 6% |
| | | | | | | | | | | | | | |
| | Total | | | | 233 | 236 | | | | | | | |
| | | | | | | | | | | | | | |
| p: Probability of capture. | | | | | | | | Ti’: Total number of fish captured. | | | | | |
| q: Probability of noncapture. | | | | | | | | xi': Total number of fish estimated in sampled units. | | | | | |
| V: Variance. | | | | | | | | n: number of sample units | | | | | |

**Table 4.** Sample Size Tables

| Sample Size Tables | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |
| Bosonberg Creek | | | Redband 1+ | | | | | | | | | |
| | | | | | | | | | | | | |
| | Habitat | | Total habitat | | | Sampled habitat | | | | Sample percent of total | | |
| Reach | Type | N | Area | Length | | n | Area | Length | | Number | Area | Length |
| All reaches | Mixed | 71 | 6,494 | 3,572 | | 28 | 2,567 | 1,412 | | 39.5% | 39.5% | 39.5% |
| | | | | | | | | | | | | |
| | Total | 71 | 6,494 | 3,572 | | 28 | 2,567 | 1,412 | | 39.5% | 39.5% | 39.5% |
| N: Total number of habitat units. | | | | | | | | | | Area in square meters | | |
| n: Number of sampled units. | | | | | | | | | | Length in meters | | |
| | | | | | | | | | | Width in meters. | | |
| | | | | | | | | | | | | |
| | Habitat | Mean habitat unit area | | | | Mean habitat unit length | | | | Mean habitat unit width | | |
| Reach | Type | Total | Sample | % diff. | | Total | Sample | % diff. | | Total | Sample | % diff. |
| All reaches | Mixed | 92 | 92 | 0.0% | | 50 | 50 | 0.0% | | 1.8 | 1.81798867 | 0.0% |
| | Total | 92 | 92 | 0.0% | | 50 | 50 | 0.0% | | 2 | 1.8 | 0.0% |

**Table 5.** Selected Estimate and Method Table

| Selected Estimate and Method Table | | | | |
|---|---|---|---|---|
| | | | | |
| Bosonberg | | Redband 1+ | | |
| | | | | |
| | Habitat | | Selected | |
| | Type | Estimate | Variance | Method |
| All reaches | Mixed | 614 | 3,553 | r #/m2 |
| | | | | |
| | Total | 614 | 3,553 | |
| p: Pooled capture method. | | | | |
| r: Regular capture method. | | | | |
| #/unit: Fish per habitat unit expansion method. | | | | |
| #/m2: Fish per square meter expansion method. | | | | |
| #/m: Fish per lineal meter expansion method. | | | | |

**Table 6.** Estimate Selection Tables

| Estimate Selection Tables | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Bosonberg | | | Redband 1+ | | |
| | all reaches | mixed | | | | | |
| | Choice of Method for Fish Population Estimation | | | | | | |
| | 1). Use Regular Capture Method | | | | | | |
| | 2). Select #/unit, #/m2, or #/m, with lowest 1st stage variance. | | | | | | |
| | 3). Place cursor on selected Pop. Est. shaded below and key "Ctrl P". | | | | | | |
| | | Pooled Capture Method | | | Regular Capture Method | | |
| | Variance | #/unit | #/$m^2$ | #/m | #/unit | #/$m^2$ | #/m |
| Selected | 1st Stage | 6,338 | 3,388 | 6,214 | 6,338 | 3,388 | 6,214 |
| Values | 2nd Stage | 30 | 30 | 30 | 165 | 165 | 165 |
| 3,553 | Total | 6,368 | 3,418 | 6,244 | 6,503 | 3,553 | 6,379 |
| r #/m2 | | | | | | | |
| 614 | Pop. Est. | 597 | 597 | 597 | 613 | 614 | 614 |
| | +/-95% CL | 156 | 115 | 155 | 158 | 117 | 157 |
| | % CL/Est. | 26% | 19% | 26% | 26% | 19% | 26% |

**Table 7.** Results Table

| Results Table | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Bosonberg Creek | | Redband 1+ | | | | | | | |
| | | | | | | | | | |
| | | | | | Fish per square meter | | | Fish per lineal meter | |
| | Habitat | Population | +/- | CL % of | | Habitat | Reach | Habitat | Reach |
| | Type | Estimate | 95% c.l. | Estimate | | Type | Average | Type | Average |
| All reaches | Mixed | 614 | 117 | 19% | | 0.0946 | | 0.172 | |
| | | 614 | 117 | 19% | | 0.0946 | | 0.172 | |

## Appendices B.
## Brook Trout Statistical Tables

**Table 8.** Reach and Total Habitat Data Input Table

| Reach and Total Habitat Data Input Table | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Total habitat | | |
| | | | | Sample strata | | Number | Area | Length |
| | | | | Reach | Habitat | of units | $m^2$ | m |
| | | | | | | | | |
| Stream: | Bosonberg Creek | | | All Reaches | Mixed | 70.8 | 6493.8 | 3572 |
| | | | | | | | | |
| Species/age: | Brook 1+ | | | | | | | |
| | | | | | | | | |
| Sample dates ("mm/dd/yy): | | | | | | | | |
| Starting | 80100 | | | | | | | |
| Ending | | | | | | | | |

**Table 9.** Electro fishing Data Tables

| Electrofishing Data Tables | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Bosonberg Creek | | | | Brook 1+ | | | | | |
| | | | | | | | | | | | | |
| | | (m2) | (m) | | | | | | | | $(yi-rxi)^2$ | |
| Unit | Unit Type | Area | Length | Pass 1 | Pass 2 | yi | p | q | V(yi) | $(yi-y)^2$ | m2 | m |
| 1 | Mixed | 107 | 50.0 | | 2 | 8.0 | 0.50 | 0.50 | 24.0 | 0 | 3 | 0 |
| 2 | Mixed | 113 | 52.0 | 9 | 1 | 10.1 | 0.89 | 0.11 | 0.2 | 3 | 0 | 2 |
| 3 | Mixed | 110 | 50.0 | 7 | 0 | 7.0 | 1.00 | 0.00 | 0.0 | 2 | 9 | 2 |
| 4 | Mixed | 158 | 50.0 | 4 | 0 | 4.0 | 1.00 | 0.00 | 0.0 | 18 | 107 | 18 |
| 5 | Mixed | 148 | 50.0 | | 0 | 1.0 | 1.00 | 0.00 | 0.0 | 53 | 152 | 52 |
| 6 | Mixed | 105 | 50.0 | 7 | 0 | 7.0 | 1.00 | 0.00 | 0.0 | 2 | 6 | 2 |
| 7 | Mixed | 122 | 50.0 | 8 | 3 | 12.8 | 0.63 | 0.38 | 10.1 | 20 | 3 | 21 |
| 8 | Mixed | | 55.0 | 7 | 5 | 24.5 | 0.29 | 0.71 | 918.8 | 263 | 226 | 239 |
| 9 | Mixed | 133 | 50.0 | | 1 | 7.2 | 0.83 | 0.17 | 0.4 | 1 | 24 | 1 |
| 10 | Mixed | 94 | 55.0 | 8 | 1 | 9.1 | 0.88 | 0.13 | 0.2 | 1 | 0 | 0 |
| 11 | Mixed | 115 | 50.0 | 9 | 2 | 11.6 | 0.78 | 0.22 | 1.5 | 11 | 1 | 11 |
| 12 | Mixed | | 50.0 | 15 | 1 | 16.1 | 0.93 | 0.07 | 0.1 | 60 | 37 | 62 |
| 13 | Mixed | 110 | 50.0 | 13 | 2 | 15.4 | 0.85 | 0.15 | 0.7 | 50 | 29 | 51 |
| 14 | Mixed | 90 | 50.0 | 12 | 2 | 14.4 | 0.83 | 0.17 | 0.8 | 37 | 39 | 38 |
| 15 | Mixed | 88 | 50.0 | 18 | 5 | 24.9 | 0.72 | 0.28 | 6.5 | 276 | 288 | 279 |
| 16 | Mixed | | 50.0 | 12 | 2 | 14.4 | 0.83 | 0.17 | 0.8 | 37 | 24 | 38 |
| 17 | Mixed | 88 | 50.0 | | 4 | 16.7 | 0.60 | 0.40 | 17.3 | 70 | 76 | 71 |
| 18 | Mixed | 60 | 50.0 | 3 | 1 | 4.5 | 0.67 | 0.33 | 2.3 | 14 | 1 | 14 |
| 19 | Mixed | 100 | 50.0 | 16 | 2 | 18.3 | 0.88 | 0.13 | 0.5 | 100 | 85 | 101 |
| 20 | Mixed | 51 | 50.0 | 4 | 1 | 5.3 | 0.75 | 0.25 | 1.0 | 9 | 1 | 8 |
| 21 | Mixed | 52 | 50 | | 3 | 0.0 | 1.00 | 0.00 | 0.0 | 69 | 22 | 68 |
| 22 | Mixed | 60 | 50 | 7 | 1 | 0.0 | 1.00 | 0.00 | 0.0 | 69 | 29 | 68 |
| 23 | Mixed | 45 | 50 | 8 | 2 | 0.0 | 1.00 | 0.00 | 0.0 | 69 | 17 | 68 |
| 24 | Mixed | 55 | 50 | 7 | 3 | 0.0 | 1.00 | 0.00 | 0.0 | 69 | 25 | 68 |
| 25 | Mixed | 65 | 50 | 4 | 1 | 0.0 | 1.00 | 0.00 | 0.0 | 69 | 35 | 68 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 | Mixed | 55 | 50 | 3 | 1 | 0.0 | 1.00 | 0.00 | 0.0 | 69 | 25 | 68 |
| 27 | Mixed | 50 | 50 | 3 | 1 | 0.0 | 1.00 | 0.00 | 0.0 | 69 | 20 | 68 |
| 28 | Mixed | 75 | 50 | 1 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 69 | 46 | 68 |

**Table 10.** Capture Statistics Table

| **Capture Statistics Table** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| Bosonberg Creek | | | | | | Brook Trout | | | | | | | |
| | | | | | | | | | | Regular capture statistics of p | | | |
| Reach | Habitat | Pooled Capture Statistics | | | | | | | | | | +/-95% | CL% |
| Strata | Strata | p' | q' | V(p') | Ti' | xi' | V(xi') | n | | avg | std dev | CL | of p |
| All Reaches | Mixed | 0.78 | 0.22 | 0.001279 | 259 | 272 | 183 | 28 | | 0.85 | 0.18 | 0.07 | 8% |
| | | | | | | | | | | | | | |
| | Total | | | | 259 | 272 | | | | | | | |
| | | | | | | | | | | | | | |
| p: Probability of capture. | | | | | | | | | | Ti': Total number of fish captured. | | | |
| q: Probability of noncapture. | | | | | | | | | | xi': Total number of fish estimated in sampled units. | | | |
| V: Variance. | | | | | | | | | | n: number of sample units | | | |

**Table 11.** Sample Size Tables

| **Sample Size Tables** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |
| Bosonberg Creek | | | Brook 1+ | | | | | | | | | |
| | Habitat | | Total habitat | | | Sampled habitat | | | | Sample percent of total | | |
| Reach | Type | N | Area | Length | | n | area | Length | | Number | Area | Length |
| All Reaches | Mixed | 71 | 6,494 | 3,572 | | 28 | 2,567 | 1,412 | | 39.5% | 39.5% | 39.5% |
| | | | | | | | | | | | | |
| | Total | 71 | 6,494 | 3,572 | | 28 | 2,567 | 1,412 | | 39.5% | 39.5% | 39.5% |
| N: Total number of habitat units. | | | | Area in square meters | | | | | | | | |
| n: Number of sampled units. | | | | Length in meters. | | | | | | | | |
| | | | | Width in meters. | | | | | | | | |
| | | | | | | | | | | | | |
| | Habitat | Mean habitat unit area | | | | Mean habitat unit length | | | | Mean habitat unit width | | |
| Reach | Type | Total | Sample | % diff. | | Total | Sample | % diff. | | Total | Sample | % diff. |
| All Reaches | Mixed | 92 | 92 | 0.0% | | 50 | 50 | 0.0% | | 1.8 | 1.81798 | 0.0% |
| | Total | 92 | 92 | 0.0% | | 50 | 50 | 0.0% | | 2 | 1.8 | 0.0% |

**Table 12.** Selected Estimate and Method Table

| Selected Estimate and Method Table | | | | |
|---|---|---|---|---|
| | | | | |
| Bosonberg | | Brook 1+ | | 80100 |
| | | | | |
| | Habitat | | Selected | |
| | Type | Estimate | Variance | Method |
| All Reaches | Mixed | 588 | 7,824 | R #/$m^2$ |
| | | | | |
| | Total | 588 | 7,824 | |
| P: Pooled capture method. | | | | |
| R: Regular captures method. | | | | |
| #/unit: Fish per habitat unit expansion method. | | | | |
| #/m2: Fish per square meter expansion method. | | | | |
| #/m: Fish per lineal meter expansion method. | | | | |

**Table 13.** Estimate Selection Tables

| Estimate Selection Tables | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | Brook 1+ | | |
| | All Reaches | Mixed | | | | | |
| | Choice of Method for Fish Population Estimation | | | | | | |
| | 1).... Use regular Capture Method. | | | | | | |
| | 2). Select #/unit, #/m2, or #/m, with lowest 1st stage variance. | | | | | | |
| | 3). Place cursor on selected Pop. Est. shaded below and key "Ctrl P". | | | | | | |
| | | Pooled Capture Method | | | Regular Capture Method | | |
| | Variance | #/unit | #/m2 | #/m | #/unit | #/$m^2$ | #/m |
| Selected | 1st Stage | 6,329 | 5,333 | 6,217 | 6,329 | 5,333 | 6,217 |
| Values | 2nd Stage | 463 | 463 | 463 | 2,491 | 2,491 | 2,491 |
| 7,824 | Total | 6,792 | 5,796 | 6,680 | 8,820 | 7,824 | 8,708 |
| R #/m2 | | | | | | | |
| 588 | Pop. Est. | 688 | 688 | 688 | 587 | 588 | 588 |
| | +/-95% CL | 162 | 149 | 160 | 184 | 173 | 183 |
| | % CL/Est. | 24% | 22% | 23% | 31% | 29% | 31% |

**Table 14.** Results Table

| Results Table | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| Bosonberg Creek | | Brook 1+ | | 80100 | - | 100600 | | | |
| | | | | | | | | | |
| | | | | | | Fish per square meter | | Fish per lineal meter | |
| | Habitat | Population | +/- | CL % of | | Habitat | Reach | Habitat | Reach |
| | Type | Estimate | 95% c.l. | Estimate | | Type | Average | Type | Average |
| All Reaches | Mixed | 588 | 173 | 29% | | 0.0905 | | 0.165 | |
| | Total | 588 | 173 | 29% | | 0.0905 | | 0.165 | |

## Appendices C.
## Sculpin Statistical Tables

**Table 15.** Reach and Total Habitat Data Input Table

| Reach and Total Habitat Data Input Table | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Total habitat | | |
| | | Sample strata | | Number | Area | Length |
| | | Reach | Habitat | Of units | $m^2$ | M |
| | | | | | | |
| Stream: | Bosonberg | All Reaches | Mixed | 70.8 | 6493.8 | 3572 |
| | | | | | | |
| Species/age: | Sculpin | | | | | |
| | | | | | | |
| Sample dates ("mm/dd/yy): | | | | | | |
| Starting | 80100 | | | | | |
| Ending | 100600 | | | | | |

**Table 16.** Electro fishing Data Tables

| Electrofishing Data Tables | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sculpin | | | | | | | | | | | | |
| | | (m2) | (m) | | | | | | | | $(yi\text{-}rxi)^2$ | |
| Unit No. | Unit Type | Area | Length | Pass 1 | Pass 2 | yi | p | q | V(yi) | $(yi\text{-}y)^2$ | m2 | M |
| 1 | Mixed | 107 | 50.0 | 21 | 8 | 33.9 | 0.62 | 0.38 | 28.7 | 2 | 50 | 1 |
| 2 | Mixed | 113 | 52.0 | 40 | 4 | 44.4 | 0.90 | 0.10 | 0.7 | 85 | 1 | 66 |
| 3 | Mixed | 110 | 50.0 | 50 | 17 | 75.8 | 0.66 | 0.34 | 40.8 | 1642 | 1121 | 1666 |
| 4 | Mixed | 158 | 50.0 | 55 | 28 | 112.0 | 0.49 | 0.51 | 370.4 | 5899 | 2621 | 5945 |
| 5 | Mixed | | 50.0 | 52 | 21 | 87.2 | 0.60 | 0.40 | 94.3 | 2703 | 932 | 2734 |
| 6 | Mixed | 105 | 50.0 | 69 | 15 | 88.2 | 0.78 | 0.22 | 10.6 | 2802 | 2286 | 2834 |
| 7 | Mixed | 122 | 50.0 | 42 | 20 | 80.2 | 0.52 | 0.48 | 186.7 | 2020 | 1119 | 2047 |
| 8 | Mixed | 105 | 55.0 | 31 | 10 | 45.8 | 0.68 | 0.32 | 20.3 | 111 | 31 | 54 |
| 9 | Mixed | | 50.0 | | 5 | 56.5 | 0.90 | 0.10 | 0.8 | 454 | 28 | 467 |
| 10 | Mixed | 94 | 55.0 | 61 | 22 | 95.4 | 0.64 | 0.36 | 64.6 | 3621 | 3537 | 3247 |
| 11 | Mixed | 115 | 50.0 | 49 | 22 | 88.9 | 0.55 | 0.45 | 155.3 | 2883 | 2000 | 2915 |
| 12 | Mixed | 110 | 50.0 | 32 | 14 | 56.9 | 0.56 | 0.44 | 87.9 | 469 | 213 | 482 |
| 13 | Mixed | 110 | 50.0 | 0 | | 0.0 | 1.00 | 0.00 | 0.0 | 1241 | 1787 | 1220 |
| 14 | Mixed | 90 | 50.0 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 1241 | 1197 | 1220 |
| 15 | Mixed | 88 | 50.0 | 5 | 2 | 8.3 | 0.60 | 0.40 | 8.6 | 724 | 650 | 708 |
| 16 | Mixed | 105 | 50.0 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 1241 | 1629 | 1220 |
| 17 | Mixed | 88 | 50.0 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 1241 | 1144 | 1220 |
| 18 | Mixed | 60 | 50.0 | 4 | 0 | 4.0 | 1.00 | 0.00 | 0.0 | 976 | 363 | 957 |
| 19 | Mixed | 100 | 50.0 | | 1 | 13.1 | 0.92 | 0.08 | 0.1 | 490 | 642 | 477 |
| 20 | Mixed | 51 | | 19 | 9 | 36.1 | 0.53 | 0.47 | 81.9 | 1 | 272 | 1 |
| 21 | Mixed | 52 | 50 | 16 | | 28.4 | 0.56 | 0.44 | 44.0 | 46 | 72 | 42 |
| 22 | Mixed | 60 | 50 | 4 | 1 | 5.3 | 0.75 | 0.25 | 1.0 | 894 | 314 | 876 |
| 23 | Mixed | 45 | | 3 | | 4.5 | 0.67 | 0.33 | 2.3 | 945 | 164 | 926 |
| 24 | Mixed | | 50 | 6 | 3 | 12.0 | 0.50 | 0.50 | 36.0 | 540 | 84 | 526 |
| 25 | Mixed | 65 | 50 | 1 | 0 | 1.0 | 1.00 | 0.00 | 0.0 | 1172 | 575 | 1152 |
| 26 | | 55 | 50 | 2 | 0 | 2.0 | 1.00 | 0.00 | 0.0 | 1105 | 366 | 1085 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27 | Mixed | 50 | 50 | | 1 | 4.5 | 0.67 | 0.33 | 2.3 | 945 | 217 | 926 |
| 28 | Mixed | 75 | 50 | 2 | 0 | 2.0 | 1.00 | 0.00 | 0.0 | 1105 | 720 | 1085 |

**Table 17.** Capture Statistics Table

| **Capture Statistics Table** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bosonberg | | Sculpin | | | | | | | | | | |
| | | | | | | | | Regular capture statistics of p | | | | |
| Reach | Habitat | Pooled Capture Statistics | | | | | | | | | +/-95% | CL% |
| Strata | Strata | p' | q' | V(p') | Ti' | xi' | V(xi') | n | avg | std dev | CL | of p |
| All Reaches | Mixed | 0.67 | 0.33 | 0.000710 | 841 | 947 | 11392 | 28 | 0.75 | 0.19 | 0.08 | 10% |
| | | | | | | | | | | | | |
| | Total | | | | 841 | 947 | | | | | | |
| | | | | | | | | | | | | |
| p: Probability of capture. | | | | | | | Ti': Total number of fish captured. | | | | | |
| q: Probability of noncapture. | | | | | | | xi': Total number of fish estimated in sampled units. | | | | | |
| V: Variance. | | | | | | | n: number of sample units | | | | | |

**Table 18.** Sample Size Tables

| **Sample Size Tables** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bosonberg | | | Sculpin | | | | | | | | |
| | Habitat | | Total habitat | | Sampled habitat | | | Sample percent of total | | | |
| Reach | Type | N | Area | Length | n | Area | Length | Number | Area | Length | |
| All Reaches | Mixed | 71 | 6,494 | 3,572 | 28 | 2,567 | 1,412 | 39.5% | 39.5% | 39.5% | |
| | | | | | | | | | | | |
| | Total | 71 | 6,494 | 3,572 | 28 | 2,567 | 1,412 | 39.5% | 39.5% | 39.5% | |
| N: Total number of habitat units. | | | | Area in square meters | | | | | | | |
| n: Number of sampled units. | | | | Length in meters. | | | | | | | |
| | | | | Width in meters. | | | | | | | |
| | | | | | | | | | | | |
| | Habitat | Mean habitat unit area | | | Mean habitat unit length | | | Mean habitat unit width | | | |
| Reach | Type | Total | Sample | % diff. | Total | Sample | % diff. | Total | Sample | % diff. | |
| All Reaches | Mixed | 92 | 92 | 0.0% | 50 | 50 | 0.0% | 1.8 | 1.81798 | 0.0% | |
| | Total | 92 | 92 | 0.0% | 50 | 50 | 0.0% | 2 | 1.8 | 0.0% | |

**Table 19.** Selected Estimate and Method Table

| Selected Estimate and Method Table | | | | |
|---|---|---|---|---|
| | | | | |
| Bosonberg | | Sculpin | | 80100 |
| | | | | |
| | Habitat | | Selected | |
| | Type | Estimate | Variance | Method |
| All Reaches | Mixed | 2,496 | 99,868 | r #/m$^2$ |
| | | | | |
| | Total | 2,496 | 99,868 | |
| p: Pooled capture method. | | | | |
| r: Regular capture method. | | | | |
| #/unit: Fish per habitat unit expansion method. | | | | |
| #/m2: Fish per square meter expansion method. | | | | |
| #/m: Fish per lineal meter expansion method. | | | | |

**Table 20.** Estimate Selection Tables

| Estimate Selection Tables | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sculpin | | | | | | | |
| | All Reaches | Mixed | | | | | |
| | Choice of Method for Fish Population Estimation | | | | | | |
| | 1)..... Use Regular Capture Method | | | | | | |
| | 2)..Select #/unit, #/m2, or #/m, with lowest 1st stage variance. | | | | | | |
| | 3)..Place cursor on selected Pop. Est. shaded below and key "Ctrl P". | | | | | | |
| | | Pooled Capture Method | | | Regular Capture Method | | |
| | Variance | #/unit | #/m2 | #/m | #/unit | #/m$^2$ | #/m |
| Selected | 1st Stage | 146,689 | 96,740 | 144,701 | 146,689 | 96,740 | 144,701 |
| Values | 2nd Stage | 28,806 | 28,806 | 28,806 | 3,128 | 3,128 | 3,128 |
| 99,868 | Total | 175,495 | 125,546 | 173,507 | 149,817 | 99,868 | 147,829 |
| r #/m2 | | | | | | | |
| 2,496 | Pop. Est. | 2,395 | 2,396 | 2,396 | 2,495 | 2,496 | 2,496 |
| | +/-95% CL | 821 | 694 | 816 | 759 | 619 | 754 |
| | % CL/Est. | 34% | 29% | 34% | 30% | 25% | 30% |

**Table 21.** Results Table

| Results Table | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| Bosonberg | | Sculpin | | 80100 | - | 100600 | | | | |
| | | | | | | | | | | |
| | | | | | | Fish per square meter | | | Fish per lineal meter | |
| | Habitat | Population | +/- | CL % of | | | Reach | | Habitat | Reach |
| | Type | Estimate | 95% c.l. | Estimate | | Type | Average | | Type | Average |
| All Reaches | Mixed | 2,496 | 619 | 25% | | 0.3844 | | | 0.699 | |
| | Total | 2,496 | 619 | 25% | | 0.3844 | | | 0.699 | |

# Salmonid Population Estimate for Crooked Creek

Author: Steve Namitz, Burns Paiute Fish and Wildlife Department, Burns, Oregon

## Introduction

Crooked Creek is a tributary of Upper Malheur River entering in at River Kilometer (RK) 8 (Figure 1). Crooked Creek is approximately 15.3 Kilometers long (9.45 miles) and has a hydrologic drainage area of roughly 79.5 Square Kilometers (31 square miles). Crooked Creek was identified by Oregon Department of Fish & Wildlife (ODFW) as a data gap for fish species in the Upper Malheur River system.

**Project #:** 199701900

**Objective 2.** Continue monitoring population trends (index) and age class structure in native salmonids within the Malheur basin.

## Methods

The Burns Paiute Tribe Fish & Wildlife Department (BPT) administered an electrofishing effort in Crooked Creek from 13 August 1999 to 9 September 1999 using ODFW protocol (Dambacher 1997). The electrofishing effort was administered to determine fish population estimates within Crooked Creek, specifically salmonids. Survey efforts were made from the confluence of Crooked Creek and the Upper Malheur River to the upper limits of fish (Figure 1 & 2).

*1999 Electro fishing Protocol*

The BPT conducted a 2/4 pass 50% reduction population survey on Crooked Creek (Figure 2). Sampled units were 50 meters in length (164 feet). Block nets were anchored into the substrate with tent pegs and rocks at the upper and lower boundary to prevent fish escapement. Survey unit #1 begins at the confluence of the Upper Malheur River and Crooked Creek (Figure 2). Surveyed units were separated by approximately 300 m (1000 ft). A total of 19 sections were sampled. Sampling was stopped when Crooked Creek became dry at River Kilometer 13.75. The first pass consists of shocking from the lower block net upstream to the upper net and back. The second pass must have a 50% reduction in the collection of age 1+ (fork length$\geq$70 mm) salmonids for the site to be complete. If more than one salmonid species is present then a 50% reduction is required for each salmonid species. If this is not met, 2 more passes were required using the same methodology. The last site for the population survey was determined when no salmonids were collected on the first pass. From this site, upper limits of *Oncorhynchus mykiss* (redband trout) and *Salvelinus fontinalis* (brook trout) were determined by shocking 100% of the wetted channel upstream until the channel became dry or intermittent. The survey was terminated due to lack of flow (dry channel).

*Fish collection*

Fish collection was accomplished with the use of a Smith & Root electrofisher. The protocol for shocking was to start at the down stream end of the block nets and shock moving upstream then back again. By the protocol this is considered to be one pass. Shocking was accomplished in groups of three, one person operating the shocker, and two netters following behind. The electrofisher was tested for effectiveness in a sample area not included in the population survey. If fish were not observed reacting to the set electrical current, instruments on the shocker were adjusted to increase the impact. After the shocker was adjusted to the appropriate settings then the survey was initiated.

Once the first pass was complete, fish were counted and sorted by species. Fish lengths and weights were measured and recorded. This procedure was repeated for all passes. The percentage of fish captured on the second pass was calculated and compared to fish captured on the first pass to determine if the process needed to be repeated again to reach the 50% reduction for salmonids. If bull trout were observed the sample site was concluded and surveyors proceeded to the next site.

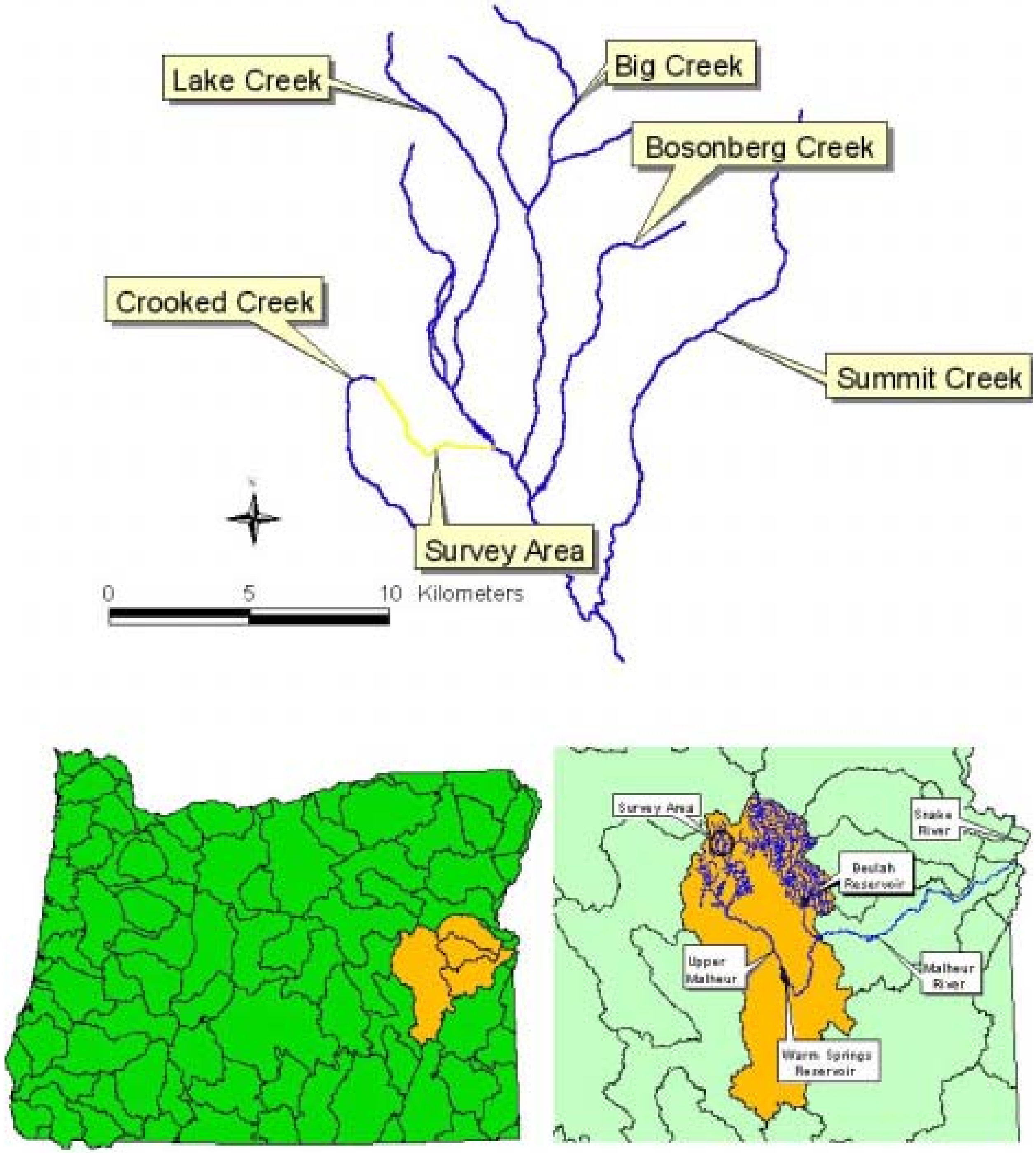


**Figure 1**. Crooked Creek Location Map

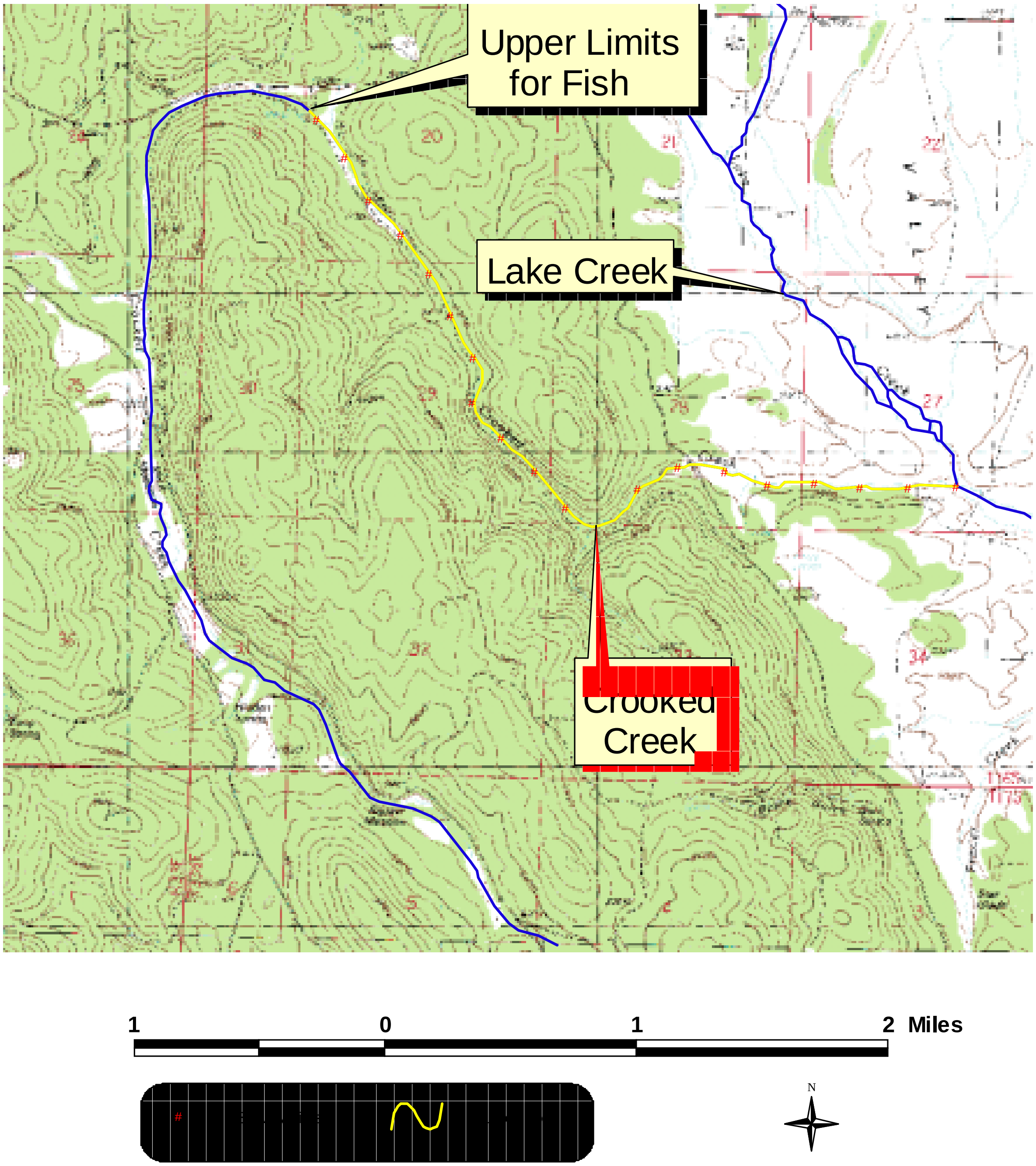


**Figure 2.** Salmonid Population Estimation and distribution survey for Crooked Creek (Malheur River, Oregon) in 2000

## Results

<u>Redband trout (*Oncorhynchus mykiss*)</u>

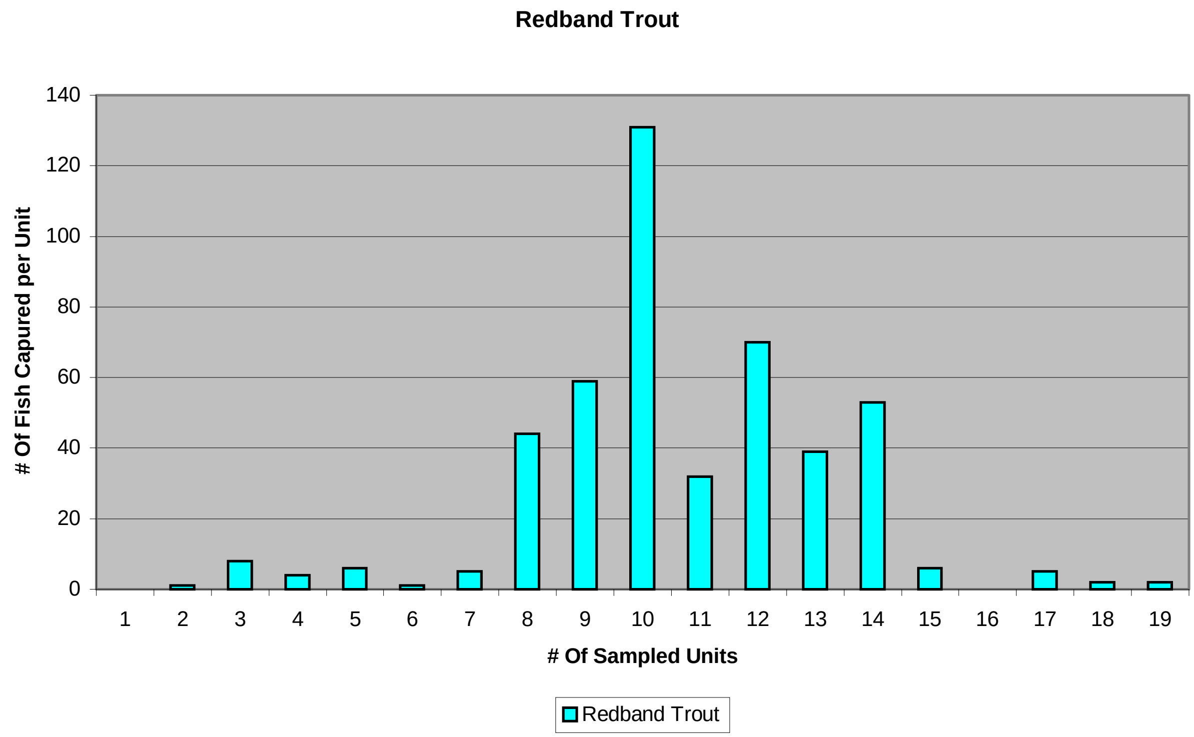


**Figure 3.** Number of redband trout captured per sample unit (1999, Crooked Creek).

There were a total of 19 sampled units with redband trout being observed in 17 of those units. A 50% reduction was achieved at every sample unit. There were 468 redband trout sampled with the average probability of capture being 81% and a probability of non-capture of 19%. Of the total surveyed area 14% was sampled. Average sample units were roughly 70 $m^2$. The estimated population of redband trout for Crooked Creek was 3,544 fish +/- 2,137 fish with a 95% confidence level (Table 1). Redband statistics tables can be viewed in Appendix A.

**Table 1**. Redband Trout Statically Results Table

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Results Table* | | | | | | | | | | |
| | | | | | | | | | | |
| Crooked Creek | | Redband Trout | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | Fish per square meter | | | Fish per lineal meter | |
| | Habitat | Population | +/- | CL % of | | Habitat | | Reach | Habitat | Reach |
| | Type | Estimate | 95% c.l. | Estimate | | Type | | Average | Type | Average |
| All reaches | Mixed | 3,544 | 2,137 | 60% | | 0.3632 | | Na | 0.508 | Na |
| | Total | 3,544 | 2,137 | 60% | | 0.3632 | | Na | 0.508 | Na |

Brook Trout (*Salvelinus fontinalis*)

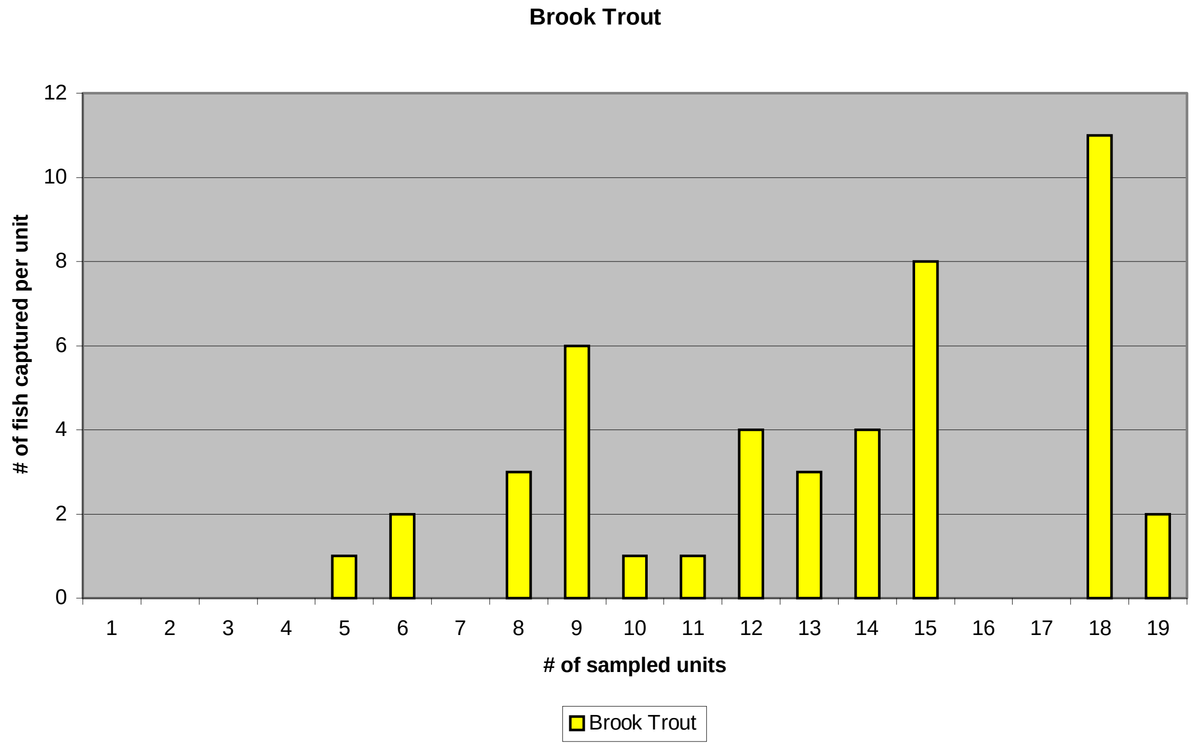


**Figure 4.** Number of brook trout captured per sample unit (1999, Crooked Creek).

Brook trout were observed periodically throughout the 19 sampled units. A 50% reduction was achieved at all sampled units where brook trout were present. There were 46 brook trout sampled with the average probability of capture being 90% and a probability of non-capture of 10%. Of the total surveyed area 14% was sampled. Average sample units were roughly 70 $m^2$. The estimated population of brook trout in Crooked Creek was 340 fish +/- 180 fish with a 95% confidence level (Table 2). Brook trout statistic tables can be viewed in Appendix B.

**Table 2**. Brook Trout Statistical Results Table

| | | | | | Fish per square meter | | Fish per lineal meter | |
|---|---|---|---|---|---|---|---|---|
| ***Results Table*** | | | | | | | | |
| Crooked Creek | Brook Trout | | | | | | | |
| | Habitat Type | Population Estimate | +/- 95% c.l. | CL % of Estimate | Habitat Type | Reach Average | Habitat Type | Reach Average |
| All reaches | Mixed | 340 | 180 | 53% | 0.0348 | Na | 0.049 | Na |
| | Total | 340 | 180 | 53% | 0.0348 | Na | 0.049 | Na |

Dace (*Rhinichthys spp*)

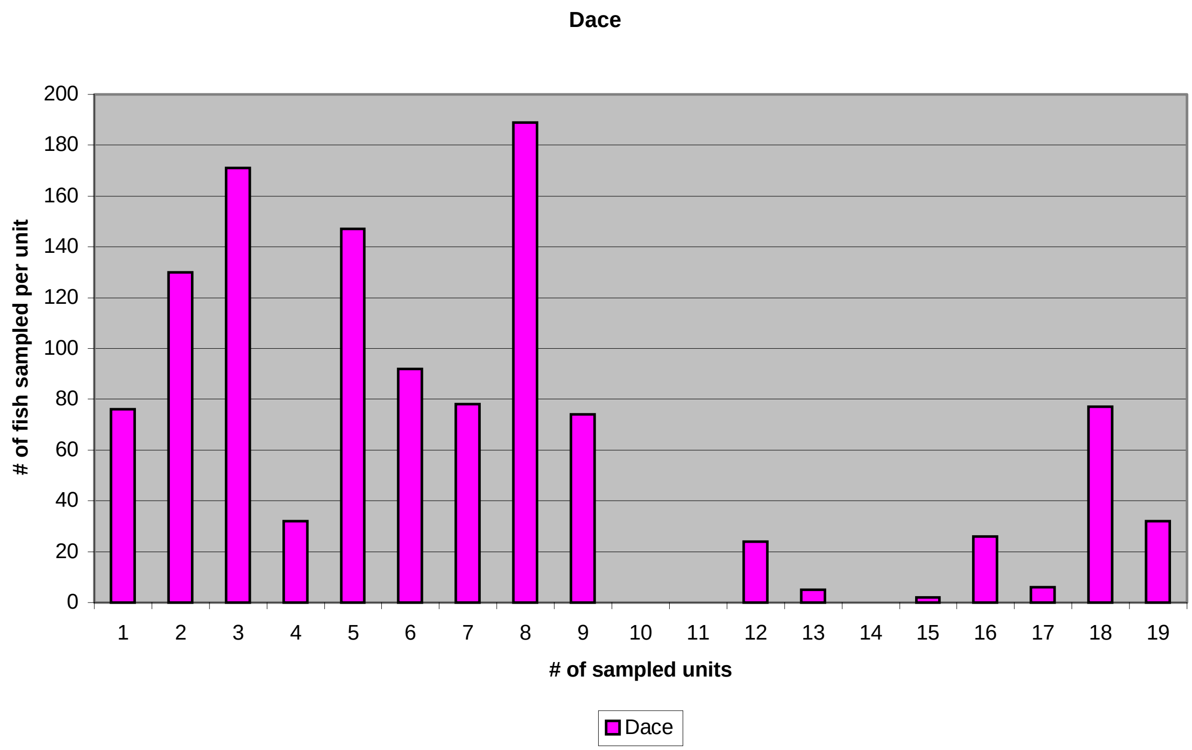


**Figure 5.** Number of dace captured per sample unit (1999, Crooked Creek).

Dace species were observed throughout Crooked Creek but were most abundant in the lower portions of the creek (Figure 5). A 50% reduction was not achieved at all sampled units because it was not a requirement of the protocol. However when making assumptions about population estimates only the sample units that achieved a 50% reduction should be used. Sample units 13 and 17 were removed from the data set to be consistent with the established protocol (Dambacher 1997). There were 1,150 dace sampled with the average probability of capture being 76% and a probability of non-capture of 24%. Of the total surveyed area 12% was sampled for dace. Average sample units were roughly 70 m$^2$. The estimated population of dace in Crooked Creek was 10,449 fish +/- 3,579 fish with a 95% confidence level (Table 3). Dace statistics tables can be viewed in Appendix C.

**Table 3.** Dace Statistical Results Table

| Results Table | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| Crooked Creek | | Dace | | | | | | | |
| | | | | | | | | | |
| | | | | | Fish per square meter | | | Fish per lineal meter | |
| | Habitat | Population | +/- | CL % of | Habitat | Reach | | Habitat | Reach |
| | Type | Estimate | 95% c.l. | Estimate | Type | Average | | Type | Average |
| All reaches | Mixed | 10,449 | 3,579 | 34% | 1.0707 | | Na | 1.499 | Na |
| | Total | 10,449 | 3,579 | 34% | 1.0707 | | Na | 1.499 | Na |

Redside Shiner *(Richardsonius balteatus)*

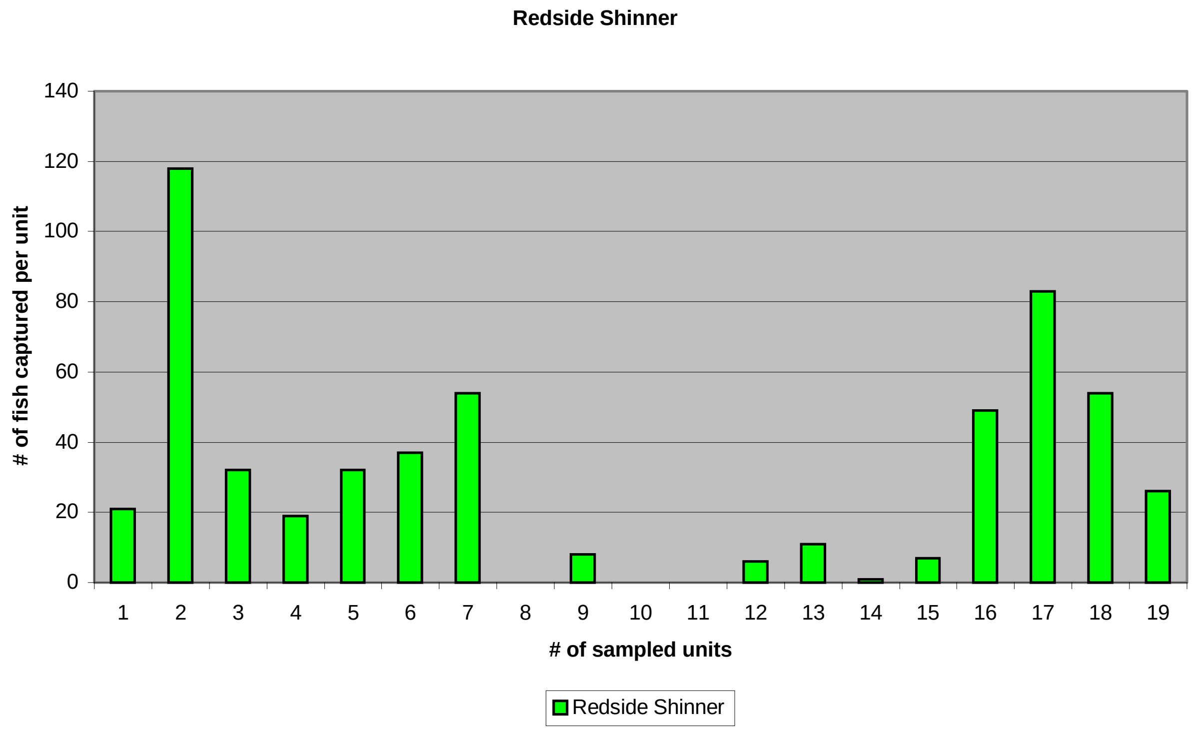


**Figure 6.** Number of redside shiners captured per sample unit (1999, Crooked Creek).

Redside shiners were observed throughout Crooked Creek but were most abundant in the lower and upper portions of the creek (Figure 6). A 50% reduction was not achieved at all sampled units because it was not a requirement of the protocol. However when making assumptions about population estimates only the sample units that achieved a 50% reduction should be used. Sample units 1, 3 and 12 were removed from the data set to be consistent with the established protocol (Dambacher 1997). There were 499 redside shiners sampled with the average probability of capture being 82% and a probability of non-capture of 18%. Of the total surveyed area 10% was sampled. Average sample units were roughly 70 m$^2$. The estimated population of redside shiners in Crooked Creek was 5,057 fish +/- 2,211 fish with a 95% confidence level (Table 4). Redside shiners statistic tables can be viewed in Appendix D.

**Table 4.** Redside Shiner Statistical Results Table

| Results Table | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| Crooked Creek | | Redside Shiner | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | Fish per square meter | | | Fish per lineal meter | |
| | Habitat | Population | +/- | CL % of | | Habitat | Reach | | Habitat | Reach |
| | Type | Estimate | 95% c.l. | Estimate | | Type | Average | | Type | Average |
| All reaches | Mixed | 5,057 | 2,211 | 44% | | 0.5182 | | Na | 0.725 | Na |
| | Total | 5,057 | 2,211 | 44% | | 0.5182 | | Na | 0.725 | Na |

Sucker *(Catostomus spp)*

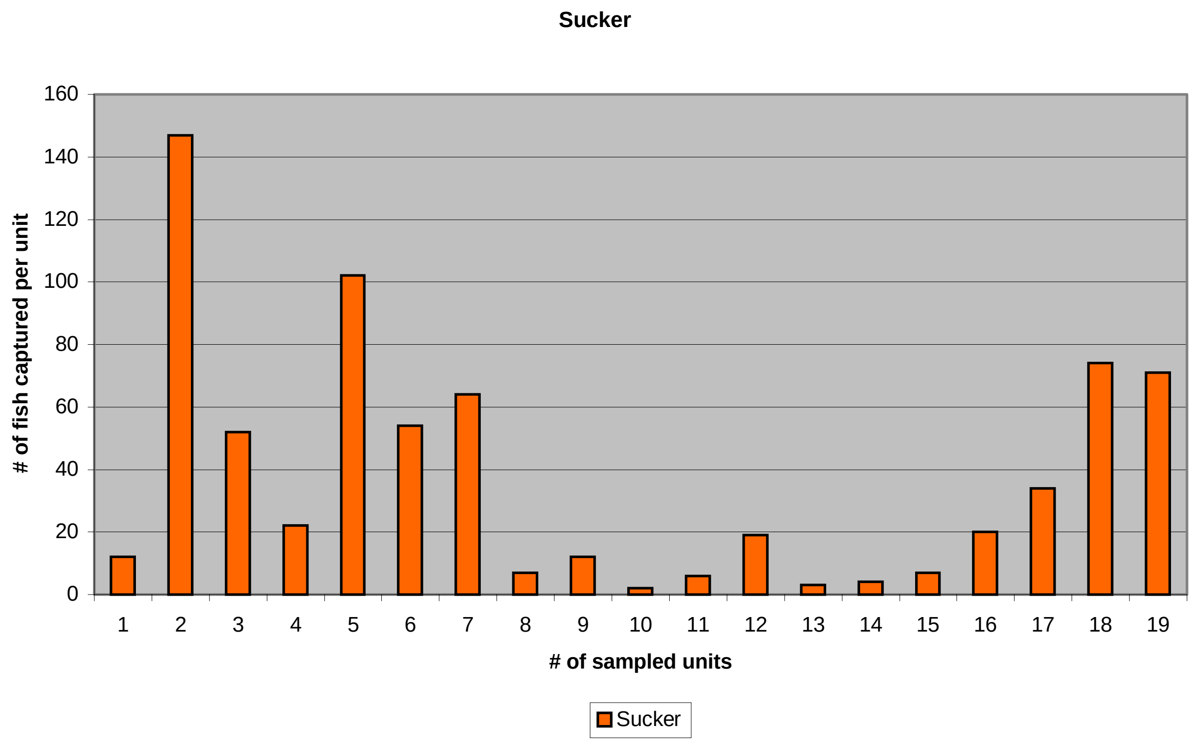


**Figure 7.** Number of suckers captured per sample unit (1999, Crooked Creek).

Suckers were observed throughout Crooked Creek but were also most abundant in the lower and upper portions of the creek (Figure 7). A 50% reduction was not achieved at all sampled units. Sample units 1 and 3 were removed from the data set to be consistent with the established protocol (Dambacher 1997). There were 648 suckers sampled with the average probability of capture being 85% and a probability of non-capture of 15%. Of the total surveyed area 12% was sampled. Average sample units were roughly 70 m$^2$. The estimated population of suckers in Crooked Creek was 6,199 fish +/- 2,684 fish with a 95% confidence level (Table 3). Suckers statistics tables can be viewed in Appendix E.

**Table 5.** Sucker Statistical Results Table

| Results Table | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Crooked Creek | | Sucker | | | | | | |
| | | | | | Fish per square meter | | Fish per lineal meter | |
| | Habitat Type | Population Estimate | +/- 95% c.l. | CL % of Estimate | Habitat Type | Reach Average | Habitat Type | Reach Average |
| All reaches | Mixed | 6,199 | 2,684 | 43% | 0.6352 | Na | 0.889 | Na |
| | Total | 6,199 | 2,684 | 43% | 0.6352 | Na | 0.889 | Na |

Sculpin *(Cottus spp)*

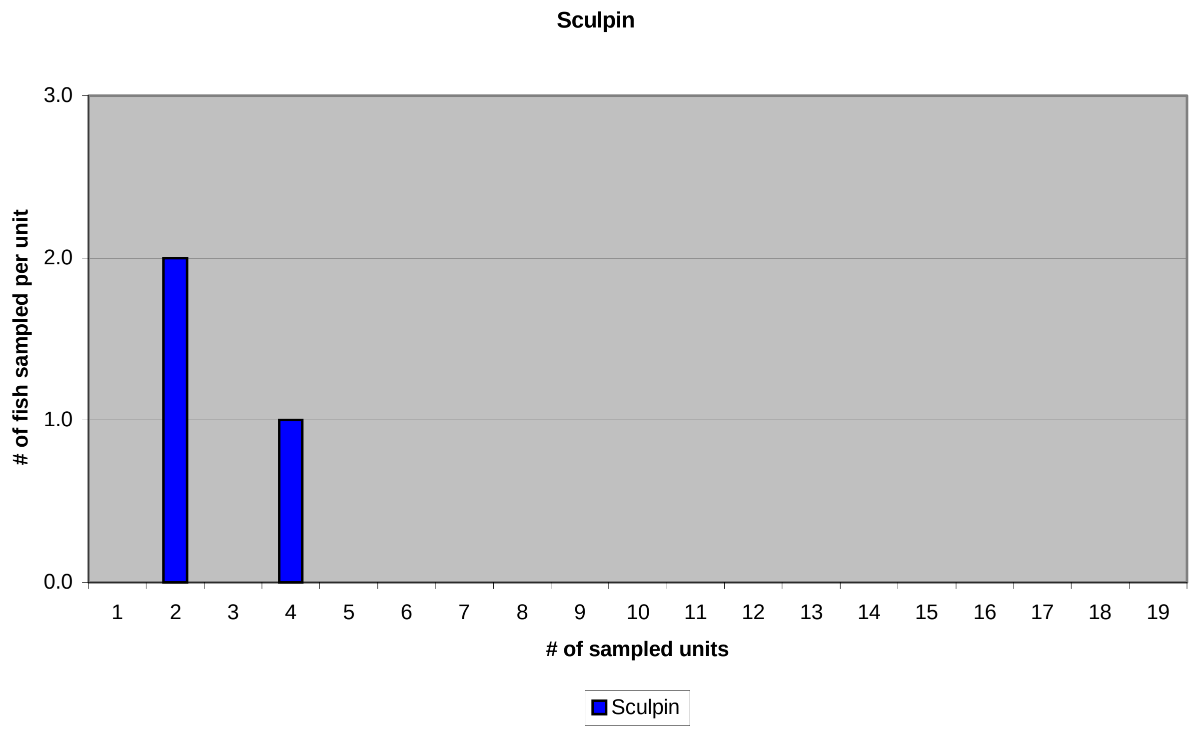


**Figure 8**. Number of sculpin captured per sample unit (1999, Crooked Creek).

Three sculpins were observed in Crooked Creek (Figure 8.). Conducting sculpin population estimates using an electrofishing method is controversial in the scientific world due to how sculpin react when being sampled. Sculpin are bottom dwellers and tend to avoid a taxis response to electrofishing. Sculpin data was collected but should be viewed as presence/absence data.

**Bull trout (*Salvenlinus confluentus*)**

No bull trout were observed within the 19 sampled units of Bosonberg Creek in 2000. How ever in 1998 the Burns Paiute Tribe Fish and Wildlife Department documented bull trout in Crooked Creek as part of a fish presence absence survey.

**Upper limits of fish species**

The upper limits of fish documented during the 1999 survey were almost exactly the same point where ODFW had established the upper limits of fish for Crooked Creek in previous studies (Personal contact, District ODFW Biologist, see figure 2).

## Discussion

Salmonids were the focus of this population estimate effort. Redband and brook trout were the salmonids sampled throughout Crooked Creek (Figure 9).

There were a total of 19 sample locations in a 6,971-meter (22,872 feet) section. The mean habitat width for the upper portion of Crooked Creek was 1.4 meters (4.6 feet), making the sampled area roughly 9,759 $m^2$ (108,433 $ft^2$).

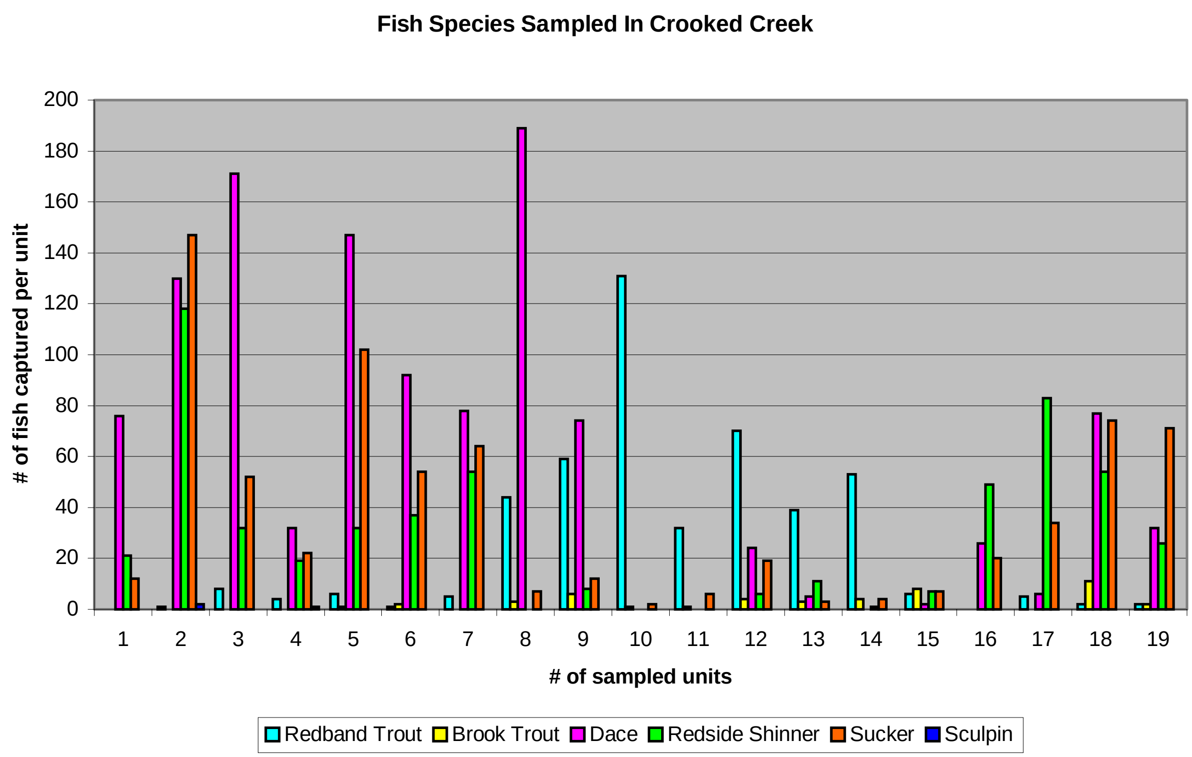


**Figure 9.** Number of fish captured per sample unit (1999, Crooked Creek).

There were no bull trout observed in Crooked Creek during the 1999 population survey, although there are historical and recent sightings of bull trout in Crooked Creek (Gonzalez et al. 1998). Current summer temperatures in Crooked Creek make it unlikely that bull trout are utilizing this area for spawning habitat although it is believed by local fish biologists that bull trout did reside in the entire drainage. Bull trout in the creek today are most likely using it as rearing or possibly winter habitat for juvenals.

Redband trout and brook trout are coinciding in the same habitat with the former being in greater abundance in 1999 (Figure 10).

There are some interesting trends that can be observed in figures 9 & 10 in regard to population interface between redband trout and non-salmonids (i.e., dace, suckers and redside shiners). The non-salmonids species populations are higher in the lower creek and in the headwaters but are reduced between sample units 9-16 (Figure 9). In contrast redband trout increase in abundance from sample units 7-15. This factor implies some sort of a transitional zone, which could be contributed to habitat change or possibly a change in water quality. This transition also occurs in the area around site 15. Causes of such a transition could include habitat, temperature (spring influence), dissolved oxygen, gradient, substrate, or a geomorphology change.

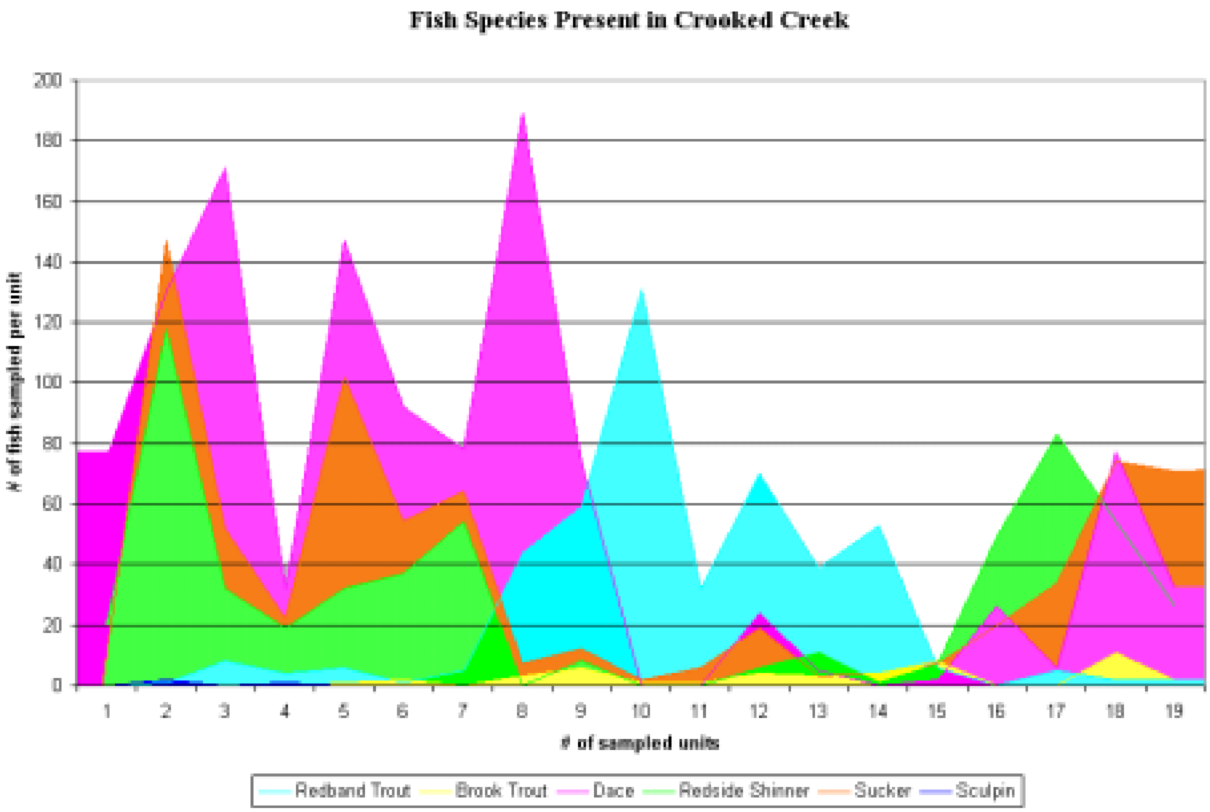


**Figure 10.** Number of fish captured per sample unit (1999, Crooked Creek).

The Crooked creek population estimate survey has provided some good base line information on what species are present in the system as well as where they reside spatially. This information will be beneficial for managers and landowners when making decisions that will possibly affect the landscape. This information also spawns more questions that will lead to future studies and restoration actions.

## Recommendations / Future Projects

The 2000 population estimates for Crooked Creek have raised some interesting questions such as why there are no bull trout currently present when they were found historically in the drainage (Bowers, 1993). Bull trout are also currently found in neighboring tributaries and in the main stem of the Upper Malheur River. Crooked Creek exhibits potential for future restoration. Potential future projects for Bosonberg Creek may include; Habitat restoration projects, exotic species eradication projects, changes in land use practices by federal agencies to favor bull trout needs. There needs to be an outreach to the private landowners to practice "Best Management

Techniques” for future land management if the salmonid species within Bosonberg Creek and the Upper Malheur Basin are to persist.

**Acknowledgements**

A special thanks is extended to ODFW, who worked with the Tribe to coordinate this effort. Thanks to Bonneville Power Administration who provided the funds to the Burns Paiute Tribe Fish and Wildlife Department to take the lead in this research.

## References

Bowers, W.L., P.A. Dupee, M.L. Hanson, and R.R. Perkins. 1993. bull trout population summary Malheur River basin. Oregon Department of Fish and Wildlife, Hines, Oregon. Unpublished report.

Bowers, W. 2001. Personal contact with employee of Oregon Department of Fish and Wildlife, Burns, Oregon.

Buchanan, M. W. and S. V. Gregory, 1997. Development of water temperature standards to protect and restore habitat for bull trout and other cold water species in Oregon. Pages 119 – 126 in McKay, W.C., M.K. Brewin, and M. Monita, editors. Friends of the bull trout conference procedding. Bull Trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary.

Buckman, R.C., W.E. Hosford, and P.A. Dupee. 1992. Malheur River bull trout investigations. Pages 45-57 *in* P.J. Howell and D.V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis.

Dambacher, J.M. 1997. Electrofishing Population Estimation Spreadsheet. Version 2.0

Dambacher, J.M. and K.K. Jones. 1997. Stream Habitat of Juvenile Bull Trout Populations in Oregon and Benchmarks for Habitat Quality. Pages 353 – 360 in McKay, W.C., M.K. Brewin, and M. Monita, editors. Friends of the bull trout conference proceeding. Bull trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary.

Gonzalez, D., Schwabe, L. and M. Tiley. 1999. Evaluate the Life History of Native Salmonids in The Malheur Basin. 1998 Annual Report. Unpublished data.

Hanson,L. M., R. C. Buckman and W. E. Hosford. 1990. Malheur River Basin Fish Management Plan. Oregon Department of Fishand Wildlife, Portland.

Howell, P.J. and D.V. Buchanan, editors. 1992. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon

Oregon Department of Fish and Wildlife. 1998. Aquatic Inventory Project: Methods for Stream Habitat Survyes, version 8.1. Natural Production Program. Corvallis, OR.

Perkins, R. 1998. Malheur River Bull Trout Population Status. Oregon Department of Fish & Wildlife. Special Report: Southeast Fisheries District. Ontario, Oregon

Ratliff, D.E. and P.J. Howell. 1992. The status of bull trout populations in Oregon. Pages 10-17 in P.J. Howell and D.V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society. Corvallis, OR.

## Appendices A.
## Redband Trout Statistical Tables

**Table 1.** Reach and Total Habitat Data Input Table

| *Reach and Total Habitat Data Input Table* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Total habitat | | |
| | | | | Sample strata | | number | area | length |
| | | | | reach | habitat | of units | m2 | m |
| | | | | | | | | |
| Stream: | Crooked Creek | | | all reaches | mixed | 136.6863 | 9759 | 6971 |
| | | | | | | | | |
| Species/age: | Redband Trout | | | | | | | |
| | | | | | | | | |
| Sample dates ("mm/dd/yy): | | | | | | | | |
| Starting | 8/13/99 | | | | | | | |
| Ending | 9/9/99 | | | | | | | |

**Table 2.** Electrofishing Data Tables

| *Electrofishing Data Tables* | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| all reaches | mixed | | Crooked Creek | | | | Redband Trout | | | | | |
| | | | | | | | | | | | | |
| | | (m2) | (m) | | | | | | | | (yi-rxi)^2 | |
| Unit No. | Unit Type | Area | Length | Pass 1 | Pass 2 | yi | p | q | V(yi) | (yi-y)^2 | m2 | m |
| 1 | mixed | 96 | 50 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 672 | 1385 | 637 |
| 2 | mixed | 105 | 50 | 1 | 0 | 1.0 | 1.00 | 0.00 | 0.0 | 621 | 1576 | 588 |
| 3 | mixed | 122 | 49 | 8 | 0 | 8.0 | 1.00 | 0.00 | 0.0 | 321 | 1528 | 274 |
| 4 | mixed | 156 | 52 | 3 | 1 | 4.5 | 0.67 | 0.33 | 2.3 | 459 | 3132 | 473 |
| 5 | mixed | 68 | 52 | 6 | 0 | 6.0 | 1.00 | 0.00 | 0.0 | 397 | 408 | 410 |
| 6 | mixed | 54 | 49 | 1 | 0 | 1.0 | 1.00 | 0.00 | 0.0 | 621 | 396 | 564 |
| 7 | mixed | 26 | 51 | 4 | 1 | 5.3 | 0.75 | 0.25 | 1.0 | 424 | 21 | 417 |
| 8 | mixed | 46 | 51 | 38 | 6 | 45.1 | 0.84 | 0.16 | 2.2 | 369 | 747 | 375 |
| 9 | mixed | 123 | 49 | 47 | 12 | 63.1 | 0.74 | 0.26 | 12.5 | 1383 | 244 | 1473 |
| 10 | mixed | 47 | 52 | 100 | 31 | 144.9 | 0.69 | 0.31 | 55.5 | 14161 | 16075 | 14083 |
| 11 | mixed | 48 | 53 | 29 | 3 | 32.3 | 0.90 | 0.10 | 0.5 | 41 | 192 | 31 |
| 12 | mixed | 48 | 53 | 60 | 10 | 72.0 | 0.83 | 0.17 | 4.0 | 2123 | 2864 | 2047 |
| 13 | mixed | 31 | 51 | 35 | 4 | 39.5 | 0.89 | 0.11 | 0.8 | 185 | 756 | 189 |
| 14 | mixed | 47 | 52 | 45 | 8 | 54.7 | 0.82 | 0.18 | 3.7 | 830 | 1339 | 811 |
| 15 | mixed | 48 | 53 | 6 | 0 | 6.0 | 1.00 | 0.00 | 0.0 | 397 | 156 | 431 |
| 16 | mixed | 47 | 52 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 672 | 329 | 689 |
| 17 | mixed | 57 | 52 | 5 | 0 | 5.0 | 1.00 | 0.00 | 0.0 | 438 | 295 | 452 |
| 18 | mixed | 59 | 54 | 2 | 0 | 2.0 | 1.00 | 0.00 | 0.0 | 572 | 442 | 638 |
| 19 | mixed | 46 | 51 | 2 | 0 | 2.0 | 1.00 | 0.00 | 0.0 | 572 | 249 | 564 |

**Table 3.** Capture Statistics Table

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Capture Statistics Table** | | | | | | | | | | | | |
| Crooked Creek | | Redband Trout | | | | | | | | | | |
| | | | | | | | | | Regular capture statistics of p | | | |
| Reach | Habitat | Pooled Capture Statistics | | | | | | | | | +/-95% | CL% |
| strata | strata | p' | q' | V(p') | Ti' | xi' | V(xi') | n | avg | std dev | CL | of p |
| all reaches | mixed | 0.81 | 0.19 | 0.000591 | 468 | 486 | 338 | 19 | 0.90 | 0.12 | 0.06 | 6% |
| | Total | | | | 468 | 486 | | | | | | |
| p: Probability of capture. | | | Ti': Total number of fish captured. | | | | | | | | | |
| q: Probability of noncapture. | | | xi': Total number of fish estimated in sampled units. | | | | | | | | | |
| V: Variance. | | | n: number of sample units | | | | | | | | | |

**Table 4.** Sample Size Tables

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Sample Size Tables* | | | | | | | | | | | |
| Crooked Creek | | | Redband Trout | | | | | | | | |
| | Habitat | | Total habitat | | | Sampled habitat | | | Sample percent of total | | |
| Reach | type | N | area | length | | n | area | length | number | area | length |
| all reaches | mixed | 137 | 9,759 | 6,971 | | 19 | 1,271 | 976 | 13.9% | 13.0% | 14.0% |
| | Total | 137 | 9,759 | 6,971 | | 19 | 1,271 | 976 | 13.9% | 13.0% | 14.0% |
| N: Total number of habitat units. | | | | Area in square meters | | | | | | | |
| n: Number of sampled units. | | | | Length in meters. | | | | | | | |
| | | | | Width in meters. | | | | | | | |
| | Habitat | Mean habitat unit area | | | | Mean habitat unit length | | | Mean habitat unit width | | |
| Reach | type | total | sample | % diff. | | total | sample | % diff. | total | sample | % diff. |
| all reaches | mixed | 71 | 67 | 5.6% | | 51 | 51 | 0.0% | 1.4 | 1.3022541 | 7.0% |
| | Total | 71 | 67 | 5.6% | | 51 | 51 | 0.0% | 1 | 1.3 | 7.1% |

**Table 5.** Selected Estimate and Method Table

| ***Selected Estimate and Method Table*** | | | | |
|---|---|---|---|---|
| | | | | |
| Crooked Creek | | Redband Trout | | |
| | | | | |
| | Habitat | | Selected | |
| | type | estimate | variance | method |
| all reaches | mixed | 3,544 | 1,188,689 | r #/unit |
| | | | | |
| | Total | 3,544 | 1,188,689 | |
| p: Pooled capture method. | | | | |
| r: Regular capture method. | | | | |
| #/unit: Fish per habitat unit expansion method. | | | | |
| #/m2: Fish per square meter expansion method. | | | | |
| #/m: Fish per lineal meter expansion method. | | | | |

**Table 6.** Estimate Selection Tables

| *Estimate Selection Tables* | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Crooked Creek | | Redband Trout | | |
| | all reaches | mixed | | | | | |
| | Choice of Method for Fish Population Estimation | | | | | | |
| | 1).....If | **6%** | < or =10%, then use Pooled Capture Method. | | | | |
| | 2)..Select #/unit, #/m2, or #/m, with lowest 1st stage variance. | | | | | | |
| | 3)..Place cursor on selected Pop. Est. shaded below and key "Ctrl P". | | | | | | |
| | | Pooled Capture Method | | | Regular Capture Method | | |
| | Variance | #/unit | #/m2 | #/m | #/unit | #/m2 | #/m |
| Selected | 1st Stage | 1,188,095 | 1,511,424 | 1,182,771 | 1,188,095 | 1,511,424 | 1,182,771 |
| Values | 2nd Stage | 2,431 | 2,431 | 2,431 | 594 | 594 | 594 |
| 1,188,689 | Total | 1,190,526 | 1,513,855 | 1,185,202 | 1,188,689 | 1,512,017 | 1,183,365 |
| r #/unit | | | | | | | |
| 3,544 | Pop. Est. | 3,496 | 3,732 | 3,473 | 3,544 | 3,783 | 3,520 |
| | +/-95% CL | 2,139 | 2,412 | 2,134 | 2,137 | 2,410 | 2,132 |
| | % CL/Est. | 61% | 65% | 61% | 60% | 64% | 61% |

**Table 7**. Results Table

| **Results Table** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| Crooked Creek | | Redband Trout | | | | | | |
| | | | | | | | | |
| | | | | | Fish per square meter | | Fish per lineal meter | |
| | Habitat | Population | +/- | CL % of | Habitat | Reach | Habitat | Reach |
| | type | estimate | 95% c.l. | estimate | type | average | type | average |
| all reaches | mixed | 3,544 | 2,137 | 60% | 0.3632 | | 0.508 | |
| | Total | 3,544 | 2,137 | 60% | 0.3632 | | 0.508 | |

# Appendix B.
# Brook Trout Statistical Tables

**Table 8.** Reach and Total Habitat Data Input Table

| Reach and Total Habitat Data Input Table | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Total habitat | | |
| | | Sample strata | | number | area | length |
| | | reach | habitat | of units | m2 | m |
| | | | | | | |
| Stream: | Crooked Creek | all reaches | | 136.6863 | | 6971 |
| | | | | | | |
| Species/age: | Brook Trout | | | | | |
| | | | | | | |
| Sample dates ("mm/dd/yy): | | | | | | |
| Starting | 8/13/99 | | | | | |
| Ending | 9/9/99 | | | | | |

**Table 9.** Electrofishing Data Tables

| Electrofishing Data Tables | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| all reaches | mixed | | Crooked Creek | | 36385 | | Brook Trout | | | | | |
| | | | | | | | | | | | | |
| | | (m2) | (m) | | | | | | | | (yi-rxi)^2 | |
| Unit No. | Unit Type | Area | Length | Pass 1 | Pass 2 | yi | p | q | V(yi) | (yi-y)^2 | m2 | m |
| 1 | mixed | 96 | 50 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 6 | 13 | 6 |
| 2 | mixed | 105 | 50 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 6 | 15 | 6 |
| 3 | mixed | 122 | 49 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 6 | 20 | 6 |
| 4 | mixed | 156 | 52 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 6 | 34 | 6 |
| 5 | mixed | 68 | 52 | 1 | 0 | 1.0 | 1.00 | 0.00 | 0.0 | 2 | 2 | 2 |
| 6 | mixed | 54 | 49 | 2 | 0 | 2.0 | 1.00 | 0.00 | 0.0 | 0 | 0 | 0 |
| 7 | mixed | 26 | 51 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 6 | 1 | 6 |
| 8 | | 46 | 51 | 3 | 0 | 3.0 | 1.00 | 0.00 | 0.0 | 0 | 2 | 0 |
| 9 | mixed | 123 | 49 | 6 | 0 | 6.0 | 1.00 | 0.00 | 0.0 | 12 | 2 | 13 |
| 10 | mixed | 47 | 52 | 1 | 0 | 1.0 | 1.00 | 0.00 | 0.0 | 2 | 1 | 2 |
| 11 | mixed | 48 | 53 | 1 | 0 | 1.0 | 1.00 | 0.00 | 0.0 | 2 | 1 | 2 |
| 12 | mixed | 48 | 53 | 3 | 1 | 4.5 | 0.67 | 0.33 | 2.3 | 4 | 7 | 4 |
| 13 | mixed | 31 | 51 | 3 | 0 | 3.0 | 1.00 | 0.00 | 0.0 | 0 | 3 | 0 |
| 14 | mixed | 47 | 52 | 3 | 1 | 4.5 | 0.67 | 0.33 | 2.3 | 4 | 8 | 4 |
| 15 | mixed | 48 | 53 | 7 | 1 | 8.2 | 0.86 | 0.14 | 0.3 | 32 | 41 | 31 |
| 16 | mixed | 47 | 52 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 6 | 3 | 6 |
| 17 | mixed | 57 | 52 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 6 | 5 | 6 |
| 18 | mixed | 59 | 54 | 10 | 1 | 11.1 | 0.90 | 0.10 | 0.2 | 74 | 79 | 72 |
| 19 | mixed | 46 | 51 | 2 | 0 | 2.0 | 1.00 | 0.00 | 0.0 | 0 | 0 | 0 |

**Table 10.** Capture Statistics Table

| Capture Statistics Table | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crooked Creek | | Brook Trout | | | | | | | | | | |
| | | | | | | | | | Regular capture statistics of p | | | |
| Reach | Habitat | Pooled Capture Statistics | | | | | | | | | +/-95% | CL% |
| strata | strata | p' | q' | V(p') | Ti' | xi' | V(xi') | n | avg | std dev | CL | of p |
| all reaches | mixed | 0.90 | 0.10 | 0.002506 | 46 | 46 | 0 | 19 | 0.95 | 0.10 | 0.05 | 5% |
| | | | | | | | | | | | | |
| | Total | | | | 46 | 46 | | | | | | |
| | | | | | | | | | | | | |
| p: Probability of capture. | | | Ti': Total number of fish captured. | | | | | | | | | |
| q: Probability of noncapture. | | | xi': Total number of fish estimated in sampled units. | | | | | | | | | |
| V: Variance. | | | n: number of sample units | | | | | | | | | |

**Table 11.** Sample Size Tables

| Sample Size Tables | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Crooked Creek | | | Brook Trout | | | | 36385 | | | | |
| | Habitat | | Total habitat | | | Sampled habitat | | | Sample percent of total | | |
| Reach | type | N | area | length | | n | area | length | number | area | length |
| all reaches | mixed | 137 | 9,759 | 6,971 | | 19 | 1,271 | 976 | 13.9% | 13.0% | 14.0% |
| | | | | | | | | | | | |
| | Total | 137 | 9,759 | 6,971 | | 19 | 1,271 | 976 | 13.9% | 13.0% | 14.0% |
| N: Total number of habitat units. | | | | Area in square meters | | | | | | | |
| n: Number of sampled units. | | | | Length in meters. | | | | | | | |
| | | | | Width in meters. | | | | | | | |
| | | | | | | | | | | | |
| | Habitat | Mean habitat unit area | | | | Mean habitat unit length | | | Mean habitat unit width | | |
| Reach | type | total | sample | % diff. | | total | sample | % diff. | total | sample | % diff. |
| all reaches | mixed | 71 | 67 | 5.6% | | 51 | 51 | 0.0% | 1.4 | 1.3022541 | 7.0% |
| | Total | 71 | 67 | 5.6% | | 51 | 51 | 0.0% | 1 | 1.3 | 7.1% |

**Table 12.** Selected Estimate and Method Table

| Selected Estimate and Method Table | | | | |
|---|---|---|---|---|
| | | | | |
| Crooked Creek | | Brook Trout | | |
| | | | | |
| | Habitat | | Selected | |
| | type | estimate | variance | method |
| all reaches | mixed | 340 | 8,409 | r #/unit |
| | | | | |
| | Total | 340 | 8,409 | |
| p: Pooled capture method. | | | | |
| r: Regular capture method. | | | | |
| #/unit: Fish per habitat unit expansion method. | | | | |
| #/m2: Fish per square meter expansion method. | | | | |
| #/m: Fish per lineal meter expansion method. | | | | |

**Table 13.** Estimate Selection Tables

| Estimate Selection Tables | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Crooked Creek | | Brook Trout | | |
| | all reaches | mixed | | | | | |
| | Choice of Method for Fish Population Estimation | | | | | | |
| | 1).....If | **5%** | < or =10%, then use Pooled Capture Method. | | | | |
| | 2)..Select #/unit, #/m2, or #/m, with lowest 1st stage variance. | | | | | | |
| | 3)..Place cursor on selected Pop. Est. shaded below and key "Ctrl P". | | | | | | |
| | | Pooled Capture Method | | | Regular Capture Method | | |
| | Variance | #/unit | #/m2 | #/m | #/unit | #/m2 | #/m |
| Selected | 1st Stage | 8,373 | 11,119 | 8,219 | 8,373 | 11,119 | 8,219 |
| Values | 2nd Stage | 1 | 1 | 1 | 36 | 36 | 36 |
| 8,409 | Total | 8,374 | 11,121 | 8,220 | 8,409 | 11,155 | 8,255 |
| r #/unit | | | | | | | |
| 340 | Pop. Est. | 331 | 353 | 329 | 340 | 363 | 338 |
| | +/-95% CL | 179 | 207 | 178 | 180 | 207 | 178 |
| | % CL/Est. | 54% | 59% | 54% | 53% | 57% | 53% |

**Table 14.** Results Table

| Results Table | | | | | | | |
|---|---|---|---|---|---|---|---|
| Crooked Creek | | Brook Trout | | | | | |
| | | | | | | | |
| | | | | | Fish per square meter | | Fish per lineal meter | |
| | Habitat | Population | +/- | CL % of | Habitat | Reach | Habitat | Reach |
| | type | estimate | 95% c.l. | estimate | type | average | type | average |
| all reaches | mixed | 340 | 180 | 53% | 0.0348 | | 0.049 | |
| | Total | 340 | 180 | 53% | 0.0348 | | 0.049 | |

# Appendix C.
# Dace Statistical Tables

**Table 15.** Reach and Total Habitat Data Input Table

| Reach and Total Habitat Data Input Table | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Total habitat | | |
| | | Sample strata | | number | area | length |
| | | reach | habitat | of units | m2 | m |
| | | | | | | |
| Stream: | Crooked Creek | all reaches | mixed | 136.6863 | 9759 | |
| | | | | | | |
| Species/age: | Dace | | | | | |
| | | | | | | |
| Sample dates ("mm/dd/yy): | | | | | | |
| Starting | 8/13/99 | | | | | |
| Ending | 9/9/99 | | | | | |

**Table 16.** Electrofishing Data Tables

| Electrofishing Data Tables | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| all reaches | mixed | | Crooked Creek | | 36385 | | Dace | | | | | |
| | | | | | | | | | | | | |
| | | (m2) | (m) | | | | | | | | (yi-rxi)^2 | |
| Unit No. | Unit Type | Area | Length | Pass 1 | Pass 2 | yi | p | q | V(yi) | (yi-y)^2 | m2 | m |
| 1 | mixed | 96 | 50 | 50 | 26 | 104.2 | 0.48 | 0.52 | 387.1 | 881 | 2 | 999 |
| 2 | mixed | 105 | 50 | 92 | 38 | 156.7 | 0.59 | 0.41 | 186.9 | 6766 | 1964 | 7087 |
| 3 | mixed | 122 | 49 | 128 | 43 | 192.8 | 0.66 | 0.34 | 99.2 | 13987 | 3927 | 14939 |
| 4 | mixed | 156 | 52 | 26 | 6 | 33.8 | 0.77 | 0.23 | 4.9 | 1655 | 17748 | 1736 |
| 5 | mixed | 68 | 52 | 130 | 17 | 149.6 | 0.87 | 0.13 | 4.4 | 5636 | 5957 | 5490 |
| 6 | mixed | 54 | 49 | 72 | 20 | 99.7 | 0.72 | 0.28 | 26.1 | 635 | 1763 | 817 |
| 7 | mixed | 26 | 51 | 78 | 0 | 78.0 | 1.00 | 0.00 | 0.0 | 12 | 2570 | 16 |
| 8 | mixed | 46 | 51 | 153 | 36 | 200.1 | 0.76 | 0.24 | 30.6 | 15773 | 22781 | 15893 |
| 9 | mixed | 123 | 49 | 58 | 16 | 80.1 | 0.72 | 0.28 | 20.5 | 31 | 2607 | 81 |
| 10 | mixed | 47 | 52 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 5548 | 2511 | 5694 |
| 11 | mixed | 48 | 53 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 5548 | 2608 | 5915 |
| 12 | mixed | 48 | 53 | 17 | 7 | 28.9 | 0.59 | 0.41 | 34.0 | 2078 | 492 | 2305 |
| | | | | | | | | | | | | |
| 14 | mixed | 47 | 52 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 5548 | 2511 | 5694 |
| 15 | mixed | 48 | 53 | 2 | 0 | 2.0 | 1.00 | 0.00 | 0.0 | 5254 | 2408 | 5612 |
| 16 | mixed | 47 | 52 | 19 | 7 | 30.1 | 0.63 | 0.37 | 22.2 | 1972 | 401 | 2059 |
| | | | | | | | | | | | | |
| 18 | mixed | 59 | 54 | 68 | 9 | 78.4 | 0.87 | 0.13 | 2.4 | 15 | 218 | 0 |
| 19 | mixed | 46 | 51 | 31 | 1 | 32.0 | 0.97 | 0.03 | 0.0 | 1802 | 293 | 1762 |

**Table 17.** Capture Statistics Table

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Capture Statistics Table** | | | | | | | | | | | | |
| Crooked Creek | | Dace | | | | | | | | | | |
| | | | | | | | | | | | | |
| 36385 | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | Regular capture statistics of p | | | |
| Reach | Habitat | Pooled Capture Statistics | | | | | | | | | +/-95% | CL% |
| strata | strata | p' | q' | V(p') | Ti' | xi' | V(xi') | n | avg | std dev | CL | of p |
| all reaches | mixed | 0.76 | 0.24 | 0.000329 | 1150 | 1223 | 5384 | 19 | 0.80 | 0.17 | 0.08 | 10% |
| | | | | | | | | | | | | |
| | Total | | | | 1150 | 1223 | | | | | | |
| | | | | | | | | | | | | |
| p: Probability of capture. | | | Ti': Total number of fish captured. | | | | | | | | | |
| q: Probability of noncapture. | | | xi': Total number of fish estimated in sampled units. | | | | | | | | | |
| V: Variance. | | | n: number of sample units | | | | | | | | | |

**Table 18.** Sample Size Tables

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sample Size Tables** | | | | | | | | | | |
| Crooked Creek | | | Dace | | | | | | | |
| | Habitat | | Total habitat | | Sampled habitat | | | Sample percent of total | | |
| Reach | type | N | area | length | n | area | length | number | area | length |
| all reaches | mixed | 137 | 9,759 | 6,971 | 19 | 1,183 | 873 | 13.9% | 12.1% | 12.5% |
| | | | | | | | | | | |
| | Total | 137 | 9,759 | 6,971 | 19 | 1,183 | 873 | 13.9% | 12.1% | 12.5% |
| N: Total number of habitat units. | | | | Area in square meters | | | | | | |
| n: Number of sampled units. | | | | Length in meters. | | | | | | |
| | | | | Width in meters. | | | | | | |
| | | | | | | | | | | |
| | Habitat | Mean habitat unit area | | | Mean habitat unit length | | | Mean habitat unit width | | |
| Reach | type | total | sample | % diff. | total | sample | % diff. | total | sample | % diff. |
| all reaches | mixed | 71 | 70 | 1.4% | 51 | 51 | 0.0% | 1.4 | 1.35509737 | 3.2% |
| | Total | 71 | 62 | 12.7% | 51 | 46 | 9.8% | 1 | 1.4 | 0.0% |

**Table 19.** Selected Estimate and Method Table

| Selected Estimate and Method Table | | | | |
|---|---|---|---|---|
| | | | | |
| Crooked Creek | | Dace | | |
| | | | | |
| | Habitat | | Selected | |
| | type | estimate | variance | method |
| all reaches | mixed | 10,449 | 3,334,156 | r #/m2 |
| | | | | |
| | Total | 10,449 | 3,334,156 | |
| p: Pooled capture method. | | | | |
| r: Regular capture method. | | | | |
| #/unit: Fish per habitat unit expansion method. | | | | |
| #/m2: Fish per square meter expansion method. | | | | |
| #/m: Fish per lineal meter expansion method. | | | | |

**Table 20.** Estimate Selection Tables

| Estimate Selection Tables | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Crooked Creek | | Dace | | |
| | all reaches | mixed | | | | | |
| | Choice of Method for Fish Population Estimation | | | | | | |
| | 1).....If | **10%** | < or =10%, then use Pooled Capture Method. | | | | |
| | 2)..Select #/unit, #/m2, or #/m, with lowest 1st stage variance. | | | | | | |
| | 3)..Place cursor on selected Pop. Est. shaded below and key "Ctrl P". | | | | | | |
| | | Pooled Capture Method | | | Regular Capture Method | | |
| | Variance | #/unit | #/m2 | #/m | #/unit | #/m2 | #/m |
| Selected | 1st Stage | 3,440,305 | 3,328,269 | 3,579,384 | 3,440,305 | 3,328,269 | 3,579,384 |
| Values | 2nd Stage | 38,731 | 38,731 | 38,731 | 5,886 | 5,886 | 5,886 |
| 3,334,156 | Total | 3,479,035 | 3,367,000 | 3,618,115 | 3,446,191 | 3,334,156 | 3,585,270 |
| r #/m2 | | | | | | | |
| 10,449 | Pop. Est. | 8,798 | 10,092 | 9,770 | 9,110 | 10,449 | 10,116 |
| | +/-95% CL | 3,656 | 3,596 | 3,728 | 3,639 | 3,579 | 3,711 |
| | % CL/Est. | 42% | 36% | 38% | 40% | 34% | 37% |

**Table 21.** Results Table

| *Results Table* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| Crooked Creek | | Dace | | | | | | |
| | | | | | | | | |
| | | | | | Fish per square meter | | Fish per lineal meter | |
| | Habitat | Population | +/- | CL % of | Habitat | Reach | Habitat | Reach |
| | type | estimate | 95% c.l. | estimate | type | average | type | average |
| all reaches | mixed | 10,449 | 3,579 | 34% | 1.0707 | | 1.499 | |
| | Total | 10,449 | 3,579 | 34% | 1.0707 | | 1.499 | |

## Appendix D.
## Redside Shinner Statistical Tables

**Table 22.** Reach and Total Habitat Data Input Table

| *Reach and Total Habitat Data Input Table* | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Total habitat | | |
| | | Sample strata | | number | area | length |
| | | reach | habitat | of units | m2 | m |
| | | | | | | |
| Stream: | Crooked Creek | all reaches | mixed | 136.6863 | 9759 | 6971 |
| | | | | | | |
| Species/age: | Redside Shinner | | | | | |
| | | | | | | |
| Sample dates ("mm/dd/yy): | | | | | | |
| Starting | 8/13/99 | | | | | |
| Ending | 9/9/99 | | | | | |

**Table 23.** Electrofishing Data Tables

| **Electrofishing Data Tables** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| all reaches | mixed | | Crooked Creek | | | | Redside Shinner | | | | | |
| | | | | | | | | | | | | |
| | | (m2) | (m) | | | | | | | | (yi-rxi)^2 | |
| Unit No. | Unit Type | Area | Length | Pass 1 | Pass 2 | yi | p | q | V(yi) | (yi-y)^2 | m2 | m |
| | | | | | | | | | | | | |
| 2 | | 105 | 50 | 91 | 27 | 129.4 | 0.70 | 0.30 | 42.5 | 9373 | 5621 | 9558 |
| | | | | | | | | | | | | |
| 4 | | 156 | 52 | 16 | 3 | 19.7 | 0.81 | 0.19 | 1.5 | 166 | 3740 | 174 |
| 5 | mixed | 68 | 52 | 28 | 4 | 32.7 | 0.86 | 0.14 | 1.2 | 0 | 6 | 0 |
| 6 | mixed | 54 | 49 | 33 | 4 | 37.6 | 0.88 | 0.12 | 0.9 | 25 | 93 | 43 |
| 7 | mixed | 26 | 51 | 48 | 6 | 54.9 | 0.88 | 0.13 | 1.4 | 497 | 1734 | 511 |
| 8 | mixed | 46 | 51 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 1061 | 566 | 1041 |
| 9 | mixed | 123 | 49 | 6 | 2 | 9.0 | 0.67 | 0.33 | 4.5 | 556 | 2968 | 484 |
| 10 | mixed | 47 | 52 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 1061 | 588 | 1082 |
| 11 | mixed | 48 | 53 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 1061 | 611 | 1124 |
| | | | | | | | | | | | | |
| 13 | mixed | 31 | 51 | 8 | 3 | 12.8 | 0.63 | 0.38 | 10.1 | 391 | 11 | 379 |
| 14 | mixed | 47 | 52 | 1 | 0 | 1.0 | 1.00 | 0.00 | 0.0 | 997 | 541 | 1017 |
| 15 | mixed | 48 | 53 | 7 | 0 | 7.0 | 1.00 | 0.00 | 0.0 | 654 | 314 | 703 |
| 16 | mixed | 47 | 52 | 41 | 8 | 50.9 | 0.80 | 0.20 | 4.4 | 337 | 712 | 326 |
| 17 | mixed | 57 | 52 | 72 | 11 | 85.0 | 0.85 | 0.15 | 3.8 | 2747 | 3063 | 2714 |
| 18 | | 59 | 54 | 48 | 6 | 54.9 | 0.88 | 0.13 | 1.4 | 497 | 580 | 429 |
| 19 | mixed | 46 | 51 | 23 | 3 | 26.5 | 0.87 | 0.13 | 0.8 | 38 | 7 | 34 |

**Table 24.** Capture Statistics Table

| Capture Statistics Table | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | |
| Crooked Creek | | Redside Shinner | | | | | | | | | | | |
| | | | | | | | | | Regular capture statistics of p | | | | |
| Reach | Habitat | Pooled Capture Statistics | | | | | | | | | | +/-95% | CL% |
| strata | strata | p' | q' | V(p') | Ti' | xi' | V(xi') | n | | avg | std dev | CL | of p |
| all reaches | mixed | 0.82 | 0.18 | 0.000511 | 499 | 516 | 299 | 17 | | 0.86 | 0.12 | 0.06 | 7% |
| | | | | | | | | | | | | | |
| | Total | | | | 499 | 516 | | | | | | | |
| | | | | | | | | | | | | | |
| p: Probability of capture. | | | Ti': Total number of fish captured. | | | | | | | | | | |
| q: Probability of noncapture. | | | xi': Total number of fish estimated in sampled units. | | | | | | | | | | |
| | | | | | | | | | | | | | |

**Table 25.** Sample Size Tables

| Sample Size Tables | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crooked Creek | | | Redside Shinner | | | | | | | | | |
| | Habitat | | Total habitat | | | Sampled habitat | | | | Sample percent of total | | |
| Reach | type | N | area | length | | n | area | length | | number | area | length |
| all reaches | mixed | 137 | 9,759 | 6,971 | | 17 | 1,006 | 824 | | 12.4% | 10.3% | 11.8% |
| | | | | | | | | | | | | |
| | Total | 137 | 9,759 | 6,971 | | 17 | 1,006 | 824 | | 12.4% | 10.3% | 11.8% |
| N: Total number of habitat units. | | | | Area in square meters | | | | | | | | |
| n: Number of sampled units. | | | | Length in meters. | | | | | | | | |
| | | | | Width in meters. | | | | | | | | |
| | | | | | | | | | | | | |
| | Habitat | Mean habitat unit area | | | | Mean habitat unit length | | | | Mean habitat unit width | | |
| Reach | type | total | sample | % diff. | | total | sample | % diff. | | total | sample | % diff. |
| all reaches | mixed | 71 | 63 | 11.3% | | 51 | 52 | -2.0% | | 1.4 | 1.22087379 | 12.8% |
| | Total | 71 | 59 | 16.9% | | 51 | 48 | 5.9% | | 1 | 1.2 | 14.3% |

**Table 26.** Selected Estimate and Method Table

| Selected Estimate and Method Table | | | | |
|---|---|---|---|---|
| | | | | |
| Crooked Creek | | Redside Shinner | | 36385 |
| | | | | |
| | Habitat | | Selected | |
| | type | estimate | variance | method |
| all reaches | mixed | 5,057 | 1,272,865 | r #/m2 |
| | | | | |
| | Total | 5,057 | 1,272,865 | |
| p: Pooled capture method. | | | | |
| r: Regular capture method. | | | | |
| #/unit: Fish per habitat unit expansion method. | | | | |
| #/m2: Fish per square meter expansion method. | | | | |
| #/m: Fish per lineal meter expansion method. | | | | |

**Table 27.** Estimate Selection Tables

| Estimate Selection Tables | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Crooked Creek | | Redside Shinner | | |
| | all reaches | mixed | | | | | |
| | Choice of Method for Fish Population Estimation | | | | | | |
| | 1).....If | **7%** | < or =10%, then use Pooled Capture Method. | | | | |
| | 2)..Select #/unit, #/m2, or #/m, with lowest 1st stage variance. | | | | | | |
| | 3)..Place cursor on selected Pop. Est. shaded below and key "Ctrl P". | | | | | | |
| | | Pooled Capture Method | | | Regular Capture Method | | |
| | Variance | #/unit | #/m2 | #/m | #/unit | #/m2 | #/m |
| Selected | 1st Stage | 1,170,406 | 1,272,282 | 1,179,848 | 1,170,406 | 1,272,282 | 1,179,848 |
| Values | 2nd Stage | 2,401 | 2,401 | 2,401 | 584 | 584 | 584 |
| 1,272,865 | Total | 1,172,807 | 1,274,682 | 1,182,248 | 1,170,990 | 1,272,865 | 1,180,431 |
| r #/m2 | | | | | | | |
| 5,057 | Pop. Est. | 4,149 | 5,007 | 4,365 | 4,191 | 5,057 | 4,409 |
| | +/-95% CL | 2,123 | 2,213 | 2,131 | 2,121 | 2,211 | 2,129 |
| | % CL/Est. | 51% | 44% | 49% | 51% | 44% | 48% |

**Table 28.** Results Table

| *Results Table* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| Crooked Creek | | Redside Shinner | | | | | | |
| | | | | | | | | |
| | | | | | Fish per square meter | | Fish per lineal meter | |
| | Habitat | Population | +/- | CL % of | Habitat | Reach | Habitat | Reach |
| | type | estimate | 95% c.l. | estimate | type | average | type | average |
| all reaches | mixed | 5,057 | 2,211 | 44% | 0.5182 | | 0.725 | |
| | Total | 5,057 | 2,211 | 44% | 0.5182 | | 0.725 | |

# Appendix E.
# Sucker Statistical Tables

**Table 29.** Reach and Total Habitat Data Input Table

| Reach and Total Habitat Data Input Table | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Total habitat | | |
| | | Sample strata | | number | area | length |
| | | reach | habitat | of units | m2 | m |
| | | | | | | |
| Stream: | Crooked Creek | all reaches | mixed | 136.6863 | 9759 | 6971 |
| | | | | | | |
| Species/age: | Sucker | | | | | |
| | | | | | | |
| Sample dates ("mm/dd/yy): | | | | | | |
| Starting | 8/13/99 | | | | | |
| Ending | 9/9/99 | | | | | |

**Table 30.** Electrofishing Data Tables

| Electrofishing Data Tables | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| all reaches | mixed | | Crooked Creek | | 36385 | | Sucker | | | | | |
| | | | | | | | | | | | | |
| | | (m2) | (m) | | | | | | | | (yi-rxi)^2 | |
| Unit No. | Unit Type | Area | Length | Pass 1 | Pass 2 | yi | p | q | V(yi) | (yi-y)^2 | m2 | m |
| | | | | | | | | | | | | |
| 2 | mixed | 105 | 50 | 118 | 29 | 156.4 | 0.75 | 0.25 | 27.4 | 13710 | 8055 | 13995 |
| | | | | | | | | | | | | |
| 4 | mixed | 156 | 52 | 17 | 5 | 24.1 | 0.71 | 0.29 | 7.7 | 233 | 5627 | 243 |
| 5 | mixed | 68 | 52 | 92 | 10 | 103.2 | 0.89 | 0.11 | 1.9 | 4078 | 3633 | 4038 |
| 6 | mixed | 54 | 49 | 46 | 8 | 55.7 | 0.83 | 0.17 | 3.5 | 266 | 460 | 335 |
| 7 | mixed | 26 | 51 | 57 | 7 | 65.0 | 0.88 | 0.12 | 1.6 | 656 | 2380 | 680 |
| 8 | mixed | 46 | 51 | 7 | 0 | 7.0 | 1.00 | 0.00 | 0.0 | 1047 | 491 | 1018 |
| 9 | mixed | 123 | 49 | 12 | 0 | 12.0 | 1.00 | 0.00 | 0.0 | 749 | 4332 | 644 |
| 10 | mixed | 47 | 52 | 2 | 0 | 2.0 | 1.00 | 0.00 | 0.0 | 1396 | 769 | 1419 |
| 11 | mixed | 48 | 53 | 5 | 1 | 6.3 | 0.80 | 0.20 | 0.6 | 1096 | 578 | 1169 |
| 12 | mixed | 48 | 53 | 16 | 3 | 19.7 | 0.81 | 0.19 | 1.5 | 387 | 113 | 430 |
| 13 | mixed | 31 | 51 | 2 | 1 | 4.0 | 0.50 | 0.50 | 12.0 | 1250 | 246 | 1219 |
| | | 47 | 52 | 4 | 0 | 4.0 | 1.00 | 0.00 | 0.0 | 1250 | 662 | 1273 |
| 15 | mixed | 48 | 53 | 6 | 1 | 7.2 | 0.83 | 0.17 | 0.4 | 1034 | 534 | 1105 |
| 16 | | 47 | 52 | 18 | 2 | 20.3 | 0.89 | 0.11 | 0.4 | 365 | 90 | 377 |
| 17 | mixed | 57 | 52 | 28 | 6 | 35.6 | 0.79 | 0.21 | 4.1 | 14 | 0 | 16 |
| 18 | mixed | 59 | 54 | 65 | 9 | 75.4 | 0.86 | 0.14 | 2.6 | 1302 | 1422 | 1173 |
| 19 | mixed | 46 | 51 | 67 | 4 | 71.3 | 0.94 | 0.06 | 0.3 | 1017 | 1772 | 1046 |

**Table 31.** Capture Statistics Table

| Capture Statistics Table | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crooked Creek | | Sucker | | | | | | | | | | |
| | | | | | | | | | Regular capture statistics of p | | | |
| Reach | Habitat | Pooled Capture Statistics | | | | | | | | | +/-95% | CL% |
| strata | strata | p' | q' | V(p') | Ti' | xi' | V(xi') | n | avg | std dev | CL | of p |
| all reaches | mixed | 0.85 | 0.15 | 0.000314 | 648 | 664 | 244 | 17 | 0.85 | 0.12 | 0.06 | 7% |
| | | | | | | | | | | | | |
| | Total | | | | 648 | 664 | | | | | | |
| | | | | | | | | | | | | |
| p: Probability of capture. | | | Ti': Total number of fish captured. | | | | | | | | | |
| q: Probability of noncapture. | | | xi': Total number of fish estimated in sampled units | | | | | | | | | |
| V: Variance. | | | | | | | | | | | | |

**Table 32.** Sample Size Tables

| Sample Size Tables | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Crooked Creek | | | Sucker | | | | 36385 | | | | |
| | Habitat | | Total habitat | | | Sampled habitat | | | Sample percent of total | | |
| Reach | type | N | area | length | | n | area | length | number | area | length |
| all reaches | mixed | 137 | 9,759 | 6,971 | | 17 | 1,053 | 877 | 12.4% | 10.8% | 12.6% |
| | | | | | | | | | | | |
| | Total | 137 | 9,759 | 6,971 | | 17 | 1,053 | 877 | 12.4% | 10.8% | 12.6% |
| N: Total number of habitat units. | | | | Area in square meters | | | | | | | |
| n: Number of sampled units. | | | | Length in meters. | | | | | | | |
| | | | | Width in meters. | | | | | | | |
| | | | | | | | | | | | |
| | Habitat | Mean habitat unit area | | | | Mean habitat unit length | | | Mean habitat unit width | | |
| Reach | type | total | sample | % diff. | | total | sample | % diff. | total | sample | % diff. |
| all reaches | mixed | 71 | 62 | 12.7% | | 51 | 52 | -2.0% | 1.4 | 1.20068415 | 14.2% |
| | Total | 71 | 62 | 12.7% | | 51 | 52 | -2.0% | 1 | 1.2 | 14.3% |

**Table 33.** Selected Estimate and Method Table

| Selected Estimate and Method Table | | | | |
|---|---|---|---|---|
| | | | | |
| Crooked Creek | | Sucker | | |
| | | | | |
| | Habitat | | Selected | |
| | type | estimate | variance | method |
| all reaches | mixed | 6,199 | 1,874,880 | r #/m2 |
| | | | | |
| | Total | 6,199 | 1,874,880 | |
| p: Pooled capture method. | | | | |
| r: Regular capture method. | | | | |
| #/unit: Fish per habitat unit expansion method. | | | | |
| #/m2: Fish per square meter expansion method. | | | | |
| #/m: Fish per lineal meter expansion method. | | | | |

**Table 34.** Estimate Selection Tables

| Estimate Selection Tables | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Crooked Creek | | Sucker | | |
| | all reaches | mixed | | | | | |
| | Choice of Method for Fish Population Estimation | | | | | | |
| | 1).....If | **7%** | < or =10%, then use Pooled Capture Method. | | | | |
| | 2)..Select #/unit, #/m2, or #/m, with lowest 1st stage variance. | | | | | | |
| | 3)..Place cursor on selected Pop. Est. shaded below and key "Ctrl P". | | | | | | |
| | | Pooled Capture Method | | | Regular Capture Method | | |
| | Variance | #/unit | #/m2 | #/m | #/unit | #/m2 | #/m |
| Selected | 1st Stage | 1,795,467 | 1,874,365 | 1,815,210 | 1,795,467 | 1,874,365 | 1,815,210 |
| Values | 2nd Stage | 1,960 | 1,960 | 1,960 | 515 | 515 | 515 |
| 1,874,880 | Total | 1,797,427 | 1,876,325 | 1,817,170 | 1,795,982 | 1,874,880 | 1,815,725 |
| r #/m2 | | | | | | | |
| 6,199 | Pop. Est. | 5,339 | 6,151 | 5,278 | 5,380 | 6,199 | 5,319 |
| | +/-95% CL | 2,628 | 2,685 | 2,642 | 2,627 | 2,684 | 2,641 |
| | % CL/Est. | 49% | 44% | 50% | 49% | 43% | 50% |

**Table 35. Results Table**

| *Results Table* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| Crooked Creek | | Sucker | | 36385 | - | 36412 | | | | |
| | | | | | | | | | | |
| | | | | | | Fish per square meter | | | Fish per lineal meter | |
| | Habitat | Population | +/- | CL % of | | Habitat | Reach | | Habitat | Reach |
| | type | estimate | 95% c.l. | estimate | | type | average | | type | average |
| all reaches | mixed | 6,199 | 2,684 | 43% | | 0.6352 | | | 0.889 | |
| | Total | 6,199 | 2,684 | 43% | | 0.6352 | | | 0.889 | |

# Appendix F.
# Sculpin Statistical Tables

**Table 36.** Reach and Total Habitat Data Input Table

| *Reach and Total Habitat Data Input Table* | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Total habitat | | |
| | | Sample strata | | number | area | length |
| | | reach | habitat | of units | m2 | m |
| | | | | | | |
| Stream: | Crooked Creek | all reaches | mixed | 136.6863 | 9759 | 6971 |
| | | | | | | |
| Species/age: | Sculpin | | | | | |
| | | | | | | |
| Sample dates ("mm/dd/yy): | | | | | | |
| Starting | 8/13/99 | | | | | |
| Ending | 9/9/99 | | | | | |

**Table 37.** Electrofishing Data Tables

| **Electrofishing Data Tables** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| all reaches | mixed | | Crooked Creek | | | | Sculpin | | | | | |
| | | | | | | | | | | | | |
| | | (m2) | (m) | | | | | | | | (yi-rxi)^2 | |
| Unit No. | Unit Type | Area | Length | Pass 1 | Pass 2 | yi | p | q | V(yi) | (yi-y)^2 | m2 | m |
| 1 | mixed | 96 | 50 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 0 | 0 | 0 |
| 2 | mixed | 105 | 50 | 0 | 2 | 0.0 | 1.00 | 0.00 | 0.0 | 0 | 0 | 0 |
| 3 | mixed | 122 | 49 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 0 | 0 | 0 |
| 4 | mixed | 156 | 52 | 1 | 0 | 1.0 | 1.00 | 0.00 | 0.0 | 1 | 1 | 1 |
| 5 | mixed | 68 | 52 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 0 | 0 | 0 |
| 6 | mixed | 54 | 49 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 0 | 0 | 0 |
| 7 | mixed | 26 | 51 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 0 | 0 | 0 |
| 8 | mixed | 46 | 51 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 0 | 0 | 0 |
| 9 | mixed | 123 | 49 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 0 | 0 | 0 |
| 10 | mixed | 47 | 52 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 0 | 0 | 0 |
| 11 | mixed | 48 | 53 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 0 | 0 | 0 |
| 12 | mixed | 48 | 53 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 0 | 0 | 0 |
| 13 | mixed | 31 | 51 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 0 | 0 | 0 |
| 14 | mixed | 47 | 52 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 0 | 0 | 0 |
| 15 | mixed | 48 | 53 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 0 | 0 | 0 |
| 16 | mixed | 47 | 52 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 0 | 0 | 0 |
| 17 | mixed | 57 | 52 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 0 | 0 | 0 |
| 18 | mixed | 59 | 54 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 0 | 0 | 0 |
| 19 | mixed | 46 | 51 | 0 | 0 | 0.0 | 1.00 | 0.00 | 0.0 | 0 | 0 | 0 |

**Table 38.** Capture Statistics Table

| Capture Statistics Table | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crooked Creek | | Sculpin | | | | | | | | | | |
| | | | | | | | | | Regular capture statistics of p | | | |
| Reach | Habitat | Pooled Capture Statistics | | | | | | | | | +/-95% | CL% |
| strata | strata | p' | q' | V(p') | Ti' | xi' | V(xi') | n | avg | std dev | CL | of p |
| all reaches | mixed | -1.00 | 2.00 | 6.000000 | 3 | -1 | 16 | 19 | 1.00 | 0.00 | 0.00 | 0% |
| | | | | | | | | | | | | |
| | Total | | | | 3 | -1 | | | | | | |
| | | | | | | | | | | | | |
| p: Probability of capture. | | | | | | | | | | | | |
| q: Probability of noncapture. | | | xi': Total number of fish estimated in sampled units. | | | | | | | | | |
| V: Variance. | | | n: number of sample units | | | | | | | | | |

**Table 39.** Sample Size Tables

| Sample Size Tables | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Crooked Creek | | | Sculpin | | | | | | | |
| | Habitat | | Total habitat | | Sampled habitat | | | Sample percent of total | | |
| Reach | type | N | area | length | n | area | length | number | area | length |
| all reaches | mixed | 137 | 9,759 | 6,971 | 19 | 1,271 | 976 | 13.9% | 13.0% | 14.0% |
| | | | | | | | | | | |
| | Total | 137 | 9,759 | 6,971 | 19 | 1,271 | 976 | 13.9% | 13.0% | 14.0% |
| N: Total number of habitat units. | | | | Area in square meters | | | | | | |
| n: Number of sampled units. | | | | Length in meters. | | | | | | |
| | | | | Width in meters. | | | | | | |
| | | | | | | | | | | |
| | Habitat | Mean habitat unit area | | | Mean habitat unit length | | | Mean habitat unit width | | |
| Reach | type | total | sample | % diff. | total | sample | % diff. | total | sample | % diff. |
| all reaches | mixed | 71 | 67 | 5.6% | 51 | 51 | 0.0% | 1.4 | 1.3022541 | 7.0% |
| | Total | 71 | 67 | 5.6% | 51 | 51 | 0.0% | 1 | 1.3 | 7.1% |

**Table 40.** Selected Estimate and Method Table

| Selected Estimate and Method Table | | | | |
|---|---|---|---|---|
| | | | | |
| Crooked Creek | | Sculpin | | |
| | | | | |
| | Habitat | | Selected | |
| | type | estimate | variance | method |
| all reaches | mixed | 0 | 0 | 0 |
| | | | | |
| | Total | 0 | 0 | |
| p: Pooled capture method. | | | | |
| r: Regular capture method. | | | | |
| #/unit: Fish per habitat unit expansion method. | | | | |
| #/m2: Fish per square meter expansion method. | | | | |
| #/m: Fish per lineal meter expansion method. | | | | |

**Table 41.** Estimate Selection Tables

| Estimate Selection Tables | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Crooked Creek | | Sculpin | | |
| all reaches | mixed | | | | 36385 | | |
| Choice of Method for Fish Population Estimation | | | | | | | |
| 1).....If | **0%** | < or =10%, then use Pooled Capture Method. | | | | | |
| 2)..Select #/unit, #/m2, or #/m, with lowest 1st stage variance. | | | | | | | |
| 3)..Place cursor on selected Pop. Est. shaded below and key "Ctrl P". | | | | | | | |
| | Pooled Capture Method | | | Regular Capture Method | | | |
| Variance | #/unit | #/m2 | #/m | #/unit | #/m2 | #/m | |
| 1st Stage | 45 | 39 | 44 | 45 | 39 | 44 | |
| 2nd Stage | 115 | 115 | 115 | 0 | 0 | 0 | |
| Total | 160 | 154 | 160 | 45 | 39 | 44 | |
| | | | | | | | |
| Pop. Est. | (7) | (8) | (7) | 7 | 8 | 7 | |
| +/-95% CL | 25 | 24 | 25 | 13 | 12 | 13 | |
| % CL/Est. | -357% | -300% | -357% | 186% | 150% | 186% | |

**Table 42.** Results Table

| Results Table | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| Crooked Creek | | Sculpin | | | | | | |
| | | | | | | | | |
| | | | | | Fish per square meter | | Fish per lineal meter | |
| | Habitat | Population | +/- | CL % of | Habitat | Reach | Habitat | Reach |
| | type | estimate | 95% c.l. | estimate | type | average | type | average |
| all reaches | mixed | 0 | 0 | #DIV/0! | 0.0000 | | 0.000 | |
| | Total | 0 | 0 | #DIV/0! | 0.0000 | | 0.000 | |